I67
no. 3
LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER
CHARLOTTENLUND SLOT – DANEMARK

JOURNAL DU CONSEIL

VOL. XIII · NO. 3

PUBLIÉ PAR LE BUREAU DU CONSEIL

RÉDIGÉ PAR
E. S. RUSSELL

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

DÉCEMBRE 1938

Notice.

The Journal of the Council appears *three times a year*, and three numbers form a volume. It includes, in addition to general articles, reviews, and bibliography, the special papers previously issued in the series of *Publications de Circonstance.*

The annual subscription price is 12 Kroner (+ Kr. 1.90 for mailing expenses) a volume, which includes, if desired, a reprint of the bibliographical matter, printed on one side of the paper. Single copies are sold at Kr. 4.50.

Orders for copies should be sent to **Messrs. Andr. Fred. Høst & Søn, Bredgade, Copenhagen.**

Correspondence, books and papers for review or bibliographical notice, and all contributions to the Journal, should be addressed to the **Assistant Editor, Journal du Conseil, Fisheries Laboratory, Lowestoft, England.**

CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER
CHARLOTTENLUND SLOT – DANEMARK

JOURNAL DU CONSEIL

VOL. XIII · NO. 3

PUBLIÉ PAR LE BUREAU DU CONSEIL

RÉDIGÉ PAR
E. S. RUSSELL

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

DÉCEMBRE 1938

A/S L. IHRICH . COPENHAGEN

Über den Zusammenhang zwischen Wind und Strom bei dem Feuerschiff Storbrotten im nördlichen Ålandsmeer.

Von

Eugenie Lisitzin,

Institut für Meeresforschung, Helsingfors.

IN einer erschöpfenden Untersuchung über die Strömungen in den Finnland umgebenden Meeren hat P a l m é n[1]) u.a. die Beziehung zwischen Wind und Strom für einige Feuerschiffe berechnet. Um dabei ein möglichst allgemeingültiges Ergebnis zu erzielen, hat P a l m é n die Beobachtungen der in dieser Hinsicht verhältnismässig günstig gelegenen Feuerschiffe Nahkiainen und Finngrundet im Bottnischen Meerbusen und Äransgrund im Finnischen Meerbusen gewählt. Wegen der im Vergleich mit den anderen Feuerschiffen freien Lage von Finngrundet wurde das hier gesammelte Material besonders eingehend behandelt.

Das im folgenden untersuchte Beobachtungsmaterial, welches von dem Feuerschiff Storbrotten stammt und den Zeitraum 1928—1936 umfasst[2]), weist nicht die Vorteile einer mehr oder weniger ausgeprägten Allgemeingültigkeit auf. In dieser Hinsicht ist vielmehr die Lage des Feuerschiffes, das in etwa NW.-Richtung von der Insel Åland im Übergangsgebiet zwischen der Bottensee und dem Ålandsmeer verankert ist (60°26′ N. Br., 19°13′ E. L.), nur wenig günstig. Da es jedoch von Interesse ist zu untersuchen, wie die lokalen Verhältnisse auf die verschiedenen Strömungsresultanten einwirken, haben wir dieses Feuerschiff gewählt. Auch in einer anderen Hinsicht ist Storbrotten den übrigen finnischen Feuerschiffen vorzuziehen. In dem fraglichen Gebiet ist nämlich die Zeit, wo Eis in nennenswerten Mengen vorkommt, verhältnismässig kurz, sodass das Feuerschiff den grössten Teil des Jahres an seiner Station verbleiben kann. Dadurch erhalten wir lange,

[1]) E. P a l m é n. Untersuchungen über die Strömungen in den Finnland umgebenden Meeren. Soc. Sc. Fenn., Comm. Phys.- Math., V. 12. Helsingfors, 1930.

[2]) Merentutkimuslaitoksen Julkaisu/Havsforskningsinstitutets Skrift: Nos. 73, 83, 94, 106 und 121. Helsingfors, 1930, 1932, 1934, 1936 und 1938.

Tabelle 1.

Die fehlenden Beobachtungsperioden.

	Zeitraum I	II	III	IV	V	VI	VII	XII	Anzahl Tage
1928.....	6—			—25					111
1929.....		8—			—10				92
1930.....			15—31						17
1931.....		8—		—25		28—	—11	29—31	94
1932.....		19—		—15		26—	7		69
1933.....	27—28	27—		—12		25—	—10		63
1934.....			3—4			22—	7		18
1935.....		28—	—2			15—	1		20
1936.....		21—		2		24—	3		52

in milden Wintern sogar fast ununterbrochene Beobachtungsreihen. Die Zeit, aus der es uns in den verschiedenen Jahren an Beobachtungen mangelt, geht aus Tab. 1 hervor. Die fehlenden Beobachtungsperioden umfassen nebst den durchschnittlich kältesten und eisreichsten Monaten Februar—März oft noch den Zeitraum Ende Juni—Mitte Juli (etwa 15 Tage), wenn das Feuerschiff für Reparation eingezogen wird. Aus der Tabelle ersehen wir, dass im Mittel während etwa 10 Monaten Beobachtungen gemacht werden. Um in dieser Hinsicht einen Vergleich mit den anderen finnischen Feuerschiffen zu geben, wollen wir erwähnen, dass das am nördlichsten gelegene Feuerschiff Kemi nur während etwa 5½ Monaten an seiner Station verbleibt. Ein weiterer Vorteil, den das Beobachtungsmaterial von Storbrotten bietet, besteht darin, dass auf diesem Feuerschiff die Beobachtungen immer dreimal täglich, nämlich um 7, 14 und 21 Uhr (O.E.Z.), gemacht werden, während auf einigen anderen Feuerschiffen die Morgen- und Abendbeobachtungen beim Einbrechen der Dunkelheit eingestellt werden. Dadurch erhalten wir einerseits eine grössere Anzahl einzelner Beobachtungen, andererseits verteilt sich das Primärmaterial gleichmässig über die ganze Beobachtungszeit.

Tabelle 2.

Resultierender Wind (m./sek.), Strom (cm./sek.) und Stabilität bei Storbrotten.

	1923		1924		1925	
Wind	N.65°W.1·3	28 %	S.46°W.1·5	36 %	N.59°W.1·1	21 %
Strom 0 m. .	N.51°W.2·0	21 %	S.88°W.1·6	22 %	N.73°W.2·4	25 %
15 m. .	N.45°W.1·8	20 %	N.83°W.1·0	16 %	N.81°W.2·7	27 %
30 m. .	N.40°W.1·7	21 %	S.79°W.0·7	12 %	S.89°W.2·0	27 %

	1926		1927		1923—26	
Wind	N.55°W.0·1	3 %	S.36°W.0·4	10 %	S.85°W.0·6	14 %
Strom 0 m. .	N.53°W.1·6	18 %	N.43°W.1·5	18 %	N.63°W.1·8	20 %
15 m. .	N.65°W.1·2	16 %	N.44°W.1·1	16 %	N.66°W.1·4	19 %
30 m. .	N.71°W.1·0	15 %	N.60°W.0·8	13 %	N.75°W.1·2	17 %

In der erwähnten Untersuchung hat Palmén auf Grund des Beobachtungsmaterials aus den Jahren 1923—1927 die Jahresresultante sowie die Stabilität[3]) des Windes und des Stroms in 0, 15 und 30 m. Tiefe auch für Storbrotten berechnet. Diese Rechenergebnisse sind in Tab. 2 wiedergegeben.

Die Jahresresultanten und die Resultanten für längere Perioden, die für die Kenntnis der mittleren Wind- und Stromverhältnisse von grosser Bedeutung sind, geben dagegen ein ziemlich verdrehtes Bild der wirklichen Verhältnisse. Die Untersuchungen von Palmén haben nämlich gezeigt, dass die Strömungen in den Baltischen Meeren vor allem vom Winde erzeugt werden, wenn man die Stromverhältnisse in einem bestimmten Zeitmoment betrachtet. Bei der Bildung von Mittelwerten für eine längere Zeitperiode tritt jedoch dieser Umstand stark zurück; der Oberflächenstrom kann sogar in einigen Fällen mit einer Komponente gegen den Wind gerichtet sein. So geht z. B. aus Tab. 2 hervor, dass die Wind- und die Oberflächenstromresultante bei Storbrotten im Jahre 1927 einen Winkel von 101° miteinander bilden. Aber auch inbetreff der einzelnen Fälle kann man nicht erwarten, dass einem bestimmten Wind immer derselbe Strom entsprechen würde. Die Strömungen hängen nämlich nicht nur von dem momentanen Wind ab, sondern es spielen dabei auch die Windveränderungen sowie die Luftdruckschwankungen eine bedeutende Rolle. Zwar ist anzunehmen, dass bei Behandlung eines grossen Materials die verschiedenen Störungen einander gewissermassen aufheben, aber dies gilt nur für den Fall, dass die Strombeobachtungen in Gruppen nach dem Winde zusammengestellt sind. Diese Gruppen müssen einerseits den verschiedenen Windgeschwindigkeiten, andererseits den Windrichtungen entsprechen. Denn wie die Stromgeschwindigkeit von der Windstärke abhängig ist, so ist der Ablenkungswinkel des Stromes eine mehr oder weniger ausgeprägte Funktion der Windrichtung. Diese Variationen der Ablenkung sind vor allem der Richtung der Küste zuzuschreiben und treten immer mehr zurück je weiter sich die Beobachtungsstation von der Küste befindet. Die Einwirkung der Küste bedingt ausserdem, dass für die Küstenstationen die Endpunkte der für die verschiedenen Windrichtungsgruppen aufgezeichneten Windvektoren nicht, wie es bei den Stationen im freien Meer der Fall ist, eine Kreislinie, sondern eine Ellipse bilden, deren grosse Achse in der Richtung der Küste fällt. Von den Strombeobachtungen als solchen muss man, um den reinen Triftstrom zu erhalten, noch die sog. permanente oder charakteristische Strömung eliminieren.

Die einfachste Methode in dieser Hinsicht, die zwar nur eine ganz rohe Schätzung des charakteristischen Stromes gestattet, geht aus Tab. 3 und 4 deutlich hervor. Jene enthält die prozentualen Häufigkeitszahlen der acht Hauptrichtungen für alle beobachteten Winde und die entsprechenden Werte in den Fällen, wo kein Oberflächenstrom vorhanden ist, in dieser sind die Frequenzzahlen mit der entsprechenden

[3]) Mit Stabilität wird der absolute Wert der Resultante, dividiert durch das arithmetische Mittel der Wind- bzw. Stromgeschwindigkeit in Prozent ausgedrückt, verstanden.

Tabelle 3.

Beobachtete Windrichtungen (Frequenz) in Prozent.

Windrichtung	N.	NE.	E.	SE.	S.	SW.	W.	NW.
Alle Winde	16	9	7	11	20	17	9	11
Winde mit Strom = 0	13	11	9	12	23	16	7	9
Differenz	3	—2	—2	—1	—3	1	2	2

Tabelle 4.

Beobachtete Windrichtungen (Frequenz × Beaufort) in Prozent.

Windrichtung	N.	NE.	E.	SE.	S.	SW.	W.	NW.
Alle Winde	17	9	6	11	20	16	9	12
Winde mit Strom = 0	14	12	7	11	23	18	6	9
Differenz	3	—3	—1	0	—3	—2	3	3

Beaufortzahl multipliziert. Ausserdem finden wir in den beiden Tabellen die Differenzen zwischen den Prozentzahlen für alle Winde und für die Winde mit gleichzeitigem Oberflächenstrom = 0. Diese Differenzen geben an, dass bei den westlichen bis nördlichen Winden Stromstille verhältnismässig seltener als bei den anderen Windrichtungen vorkommt. Dies besagt, dass die Richtung des charakteristischen Stromes etwa nordwestlich ist.

Eine andere, viel genauere Methode für die Bestimmung des charakteristischen Stromes besteht in der Bildung der Resultante für diejenigen Ströme, die bei Windstille beobachtet wurden. Da die Anzahl solcher Beobachtungen 377 beträgt, können wir annehmen, dass die verschiedenen störenden Einflüsse einander aufheben. Die berechneten Werte für Stromresultante und Stabilität in drei verschiedenen Tiefen sind

0 m. Tiefe	N.48°W.	0·9 cm./sek.	24 %
15 m. Tiefe	N.64°W.	0·8 cm./sek.	24 %
30 m. Tiefe	N.78°W.	0·6 cm./sek.	22 %

Tabelle 5.

Charakteristische Strömung.

(Ausgeglichene Werte).

Windstärke	Charakteristische Strömung
1 B	N.60°W. 0·6 cm./sek.
2 B	N.55°W. 0·7 „
3 B	N.50°W. 0·8 „
4 B	N.45°W. 1·1 „
5 B	N.40°W. 1·5 „
6 B	N.30°W. 1·9 „
7 B	N.20°W. 2·5 „
8 B	N.10°W. 3·2 „
9 B	N. 4·0 „

Es sei erwähnt, dass diese Richtungen mit den oben (Tab. 2) angeführten Stromresultanten für die Zeitperiode 1923—1927 ziemlich gut übereinstimmen.

Die Untersuchungen von Palmén haben gezeigt, dass die Geschwindigkeit des charakteristischen Stromes eine Funktion der Windstärke ist. Gerade deshalb hat Palmén die Benennung charakteristische Strömung statt permanente Strömung benutzt. Die Bestimmung des charakteristischen Stromes für die verschiedenen Windstärken geschieht in der Weise, dass die Resultante der den acht Hauptrichtungen entsprechenden Stromvektoren gebildet wird. Danach erhalten wir für die Windstärken 1—9 B die in Tab. 5 zusammengestellten ausgeglichenen Werte.

Die Resultierende dieser ausgeglichenen Werte beträgt

N.22°W. 1·7 cm./sek.,

während die Resultante der entsprechenden unausgeglichenen Stromvektoren

N.30°W. 1·8 cm./sek.

ist. Die beiden Stromgeschwindigkeiten stimmen somit ziemlich gut überein. Die Richtungen weichen dagegen mit 8° voneinander ab, was darauf beruht, dass die unausgeglichenen Stromvektoren, die sich mit wachsender Windstärke immer mehr der nördlichen Richtung nähern, für die Windstärken 8 und 9 B eine unerwartet grosse westliche Komponente haben.

Ausser den obenerwähnten Methoden haben wir noch eine Möglichkeit, die Richtigkeit der obigen Werte zu prüfen und den charakteristischen Strom wenigstens annähernd zu bestimmen. Diese Möglichkeit besteht in einer numerischen Anwendung der von Sverdrup[4]) vorgeschlagenen graphischen Methode für die Bestimmung der permanenten Strömung. Wir bilden den Mittelwert der den Windstärken 1—9 B entsprechenden Stromgeschwindigkeiten für die acht Hauptrichtungen und unterwerfen die in dieser Weise erhaltenen Daten einer harmonischen Analyse. Dabei stossen wir zwar auf eine Schwierigkeit. Die Ablenkung der Stromrichtung von der Windrichtung variiert nämlich innerhalb der Grenzen —6° (für die NE.-Richtung) und 21° (für die W.-Richtung). Um die Rechnungen zu vereinfachen, nehmen wir jedoch an, dass die Ablenkung für alle Windrichtungen 10° beträgt, welcher Wert der mittleren Ablenkung entspricht. In dieser Weise erhalten wir die Gleichung

$$c = 12{\cdot}1 + 0{\cdot}9 \cos (294° - v) + 2{\cdot}0 \cos 2 (142° - v)$$

wo c die Stromgeschwindigkeit (cm./sek.) und v die Stromrichtung bedeutet. Das erste Glied dieser Gleichung gibt einen Kreis mit dem Radius 12·1 und entspricht der mittleren Stromgeschwindigkeit. Das zweite Glied besagt eine Verschiebung des Kreises um 0·9 cm. in der

[4]) H. U. Sverdrup. The Waters on the North-Siberian Shelf. The Norwegian North Polar Expedition with the "Maud" 1918—1925, Scientific Results, Vol. IV, No. 2. Bergen, 1929.

Tabelle 6.

Beobachtete und berechnete rohe Stromgeschwindigkeiten (cm./sek.).

Windrichtung	N.	NE.	E.	SE.	S.	SW.	W.	NW.
Beobachtet	12·9	9·4	11·3	12·8	12·9	9·6	13·9	14·0
Berechnet	12·6	9·6	11·0	13·3	12·0	10·6	12·8	14·9
Differenz	0·3	—0·2	0·3	—0·5	0·9	—1·0	1·1	—0·9

Tabelle 7.

Wind und reduzierter Strom (cm./sek.) bei Storbrotten.

(α = Ablenkungswinkel).

Wind.	NE.		E.		SE.	
	Strom	α	Strom	α	Strom	α
1 B	N.80°E. 1·4	35°	N.76°E. 1·4	—14°	S.31°E. 3·1	14°
2 B	N.62°E. 2·6	17°	S.85°E. 4·1	5°	S. 7°E. 3·8	38°
3 B	N.59°E. 2·2	14°	N.74°E. 2·4	—16°	S.37°E. 5·8	8°
4 B	N.42°E. 8·2	—3°	S.88°E. 8·9	2°	S.38°E. 6·5	7°
5 B	N.56°E. 9·6	11°	S.80°E. 11·7	10°	S.38°E. 11·1	7°
6 B	N.45°E. 12·1	0°	N.88°E. 15·0	—2°	S.23°E. 11·6	22°
7 B	N.41°E. 12·8	—4°	S.41°E. 14·2	49°	S.37°E. 18·3	8°
8 B	N.32°E. 18·0	—13°	S.58°E. 23·3	32°	S.19°E. 27·4	26°
9 B	N.47°E. 18·0	2°	(S.60°E. 27·0)	30°	S.25°E. 33·9	20°

Wind.	S.		SW.		W.	
	Strom	α	Strom	α	Strom	α
1 B	S.18°W. 2·8	18°	S.56°W. 2·4	11°	N.20°W. 1·1	70°
2 B	S. 5°W. 2·7	5°	S.51°W. 2·1	6°	N.78°W. 3·1	12°
3 B	S.15°E. 4·2	—15°	S.41°W. 3·4	—4°	S.75°W. 3·9	—15°
4 B	S. 5·3	0°	S.41°W. 6·0	—4°	N.86°W. 12·3	4°
5 B	S. 2°W. 7·8	2°	S.41°W. 10·5	—4°	N.66°W. 18·6	24°
6 B	S.16°W. 15·2	16°	S.40°W. 14·7	—5°	N.66°W. 23·3	24°
7 B	S. 1°W. 18·7	1°	S.66°W. 11·0	21°	N.59°W. 17·2	31°
8 B	S. 3°W. 26·9	3°	S.51°W. 21·4	6°	S.87°W. 10·4	—3°
9 B	S. 3°W. 35·9	3°	S.37°W. 14·0	—8°	N.65°W. 29·1	25°

Wind.	NW.		N.	
	Strom	α	Strom	α
1 B	N.29°W. 1·5	16°	N.31°E. 1·3	31°
2 B	N.34°W. 2·0	11°	N.19°E. 2·8	19°
3 B	N.34°W. 4·7	11°	N.30°E. 4·7	30°
4 B	N.39°W. 7·6	6°	N. 9°E. 5·1	9°
5 B	N.12°W. 13·8	33°	N.17°E. 9·4	17°
6 B	N. 9°W. 15·9	36°	N.16°E. 17·4	16°
7 B	N.10°W. 16·9	35°	N. 9°E. 18·1	9°
8 B	N.22°W. 24·4	23°	N. 2°E. 23·2	2°
9 B	N.27°W. 32·5	18°	N. 3°E. 29·8	3°

Richtung N.66°W. Dieser Wert gibt somit den mittleren charakteristischen Strom wieder. Das dritte Glied ist durch die Elliptizität bedingt. Die grosse Achse dieser Ellipse würde 7° rechts von der Richtung SE.—NW. fallen und somit gut mit der Richtung der schwedischen Küste am nördlichen Ålandsmeer übereinstimmen.

In Tab. 6 finden wir die Ausgangswerte verglichen mit den nach der obigen Gleichung berechneten Werten nebst den entsprechenden Differenzen. Aus dieser Tabelle geht hervor, dass die Differenzen abwechselnd positiv und negativ sind.

Die Geschwindigkeit des charakteristischen Stromes ist mit der bei Windstille berechneten identisch, die Richtungen weichen dagegen um 18° voneinander ab. Die Anwendung der mit der Windstärke veränderlichen charakteristischen Strömung würde dagegen eine allzu starke Verschiebung des Mittelpunktes der kreis- bzw. ellipsenähnlichen Kurve in NNW.-Richtung besagen.

Mit Rücksicht auf das oben Gesagte entschlossen wir uns dafür, bei der Reduzierung der Strombeobachtungen den charakteristischen Strom gleich

N.48°W. 0·9 cm./sek.

zu wählen. Auf diese Weise erhielten wir für die verschiedenen Windrichtungen und -stärken die in Tab. 7 zusammengestellten Werte.

Auch diese Werte wurden einer harmonischen Analyse unterworfen. Als mittlere Abweichung der Stromrichtung von der Windrichtung wurde dabei 12° benutzt. Die erhaltene Gleichung lautet:

$$c = 12{\cdot}1 + 0{\cdot}4 \cos (234° - v) + 2{\cdot}0 \cos 2 (143° - v).$$

Wie zu erwarten war, hat sich nur das zweite Glied nennenswert verändert, indem die Amplitude um mehr als die Hälfte kleiner wurde und die Richtung eine Verschiebung um 60° nach links erhielt. Die Bedeutung dieses Gliedes für das ganze Resultat wurde dadurch in hohem Mass reduziert. Sein Betrag macht höchstens 4 % des übrigen Effektes aus. Die Ausgangswerte, die berechneten Werte und die

Tabelle 8.

Beobachtete und berechnete reduzierte Stromgeschwindigkeiten (cm./sek.).

Windrichtung	N.	NE.	E.	SE.	S.	SW.	W.	NW.
Beobachtet	12·4	9·4	12·0	13·5	13·3	9·5	13·2	13·3
Berechnet	11·7	9·7	11·9	14·1	12·3	10·5	12·5	14·1
Differenz	0·7	—0·3	0·1	—0·6	1·0	—1·0	0·7	—0·8

entsprechenden Differenzen sind in Tab. 8 zusammengestellt. Das Ergebnis kann noch derart verbessert werden, dass wir der Gleichung ein viertes Glied hinzufügen. Die abwechselnd positiven und negativen

Differenzen deuten darauf hin, dass dieses Glied am zweckmässigsten als ein vierperiodisches gewählt werden soll, nämlich

$$0{\cdot}7 \cos 4\ (12^\circ - v),$$

wodurch die berechneten Werte im Sinne des Uhrzeigers von N. bis NW. die folgende Reihe bilden:

12·4 9·0 12·6 13·4 13·0 9·8 13·2 13·4 cm./sek.

Die maximale numerische Abweichung beträgt in diesem Fall 0·6 cm./sek., was 5 % des absoluten Betrags ausmacht. Das letzterwähnte Glied ist durch die Einwirkung der Insel Åland bedingt.

Gehen wir dazu über, die Beziehung zwischen Wind- und Stromgeschwindigkeit zu untersuchen, so besteht das gewöhnliche Verfahren darin, den arithmetischen Mittelwert der den acht Hauptwindrichtungen entsprechenden Stromvektoren für die verschiedenen Windstärken zu bilden. In dieser Weise werden auch die Ablenkungen der Stromrichtung von der Windrichtung oder richtiger die Schwankungen der Ablenkung einigermassen berücksichtigt. Die Resultante wird nämlich um so kleiner, je mehr die einzelnen Stromvektoren zerstreut sind.

Eine viel einfachere Methode besteht in der Bildung der einer bestimmten Windstärke entsprechenden mittleren Stromgeschwindigkeiten. Eine Untersuchung dieser Mittelwerte hat ergeben, dass die Beziehung zwischen Windstärke und Stromgeschwindigkeit quadratisch ist. Bei der Benutzung der Methode der kleinsten Quadrate erhalten wir die Gleichung

$$y = 0{\cdot}35\ x^2 + 3{\cdot}9,$$

wo x die in Beaufort ausgedrückte Windstärke und y die Stromgeschwindigkeit in cm./sek. bedeutet. Tab. 9 liefert einen Vergleich

Tabelle 9.

Beobachtete und berechnete Stromgeschwindigkeiten (cm./sek.).

Wind.		0B	1B	2B	3B	4B	5B	6B	7B	8B	9B	10B
Strom	Beob. ...	3·7	4·9	5·2	6·9	9·0	13·4	17·2	19·7	25·3	32·9	38·9
	Ber.	3·9	4·3	5·3	7·1	9·5	12·7	16·5	21·1	26·3	32·3	38·9

zwischen den beobachteten und den berechneten Stromgeschwindigkeiten für die Windstärken 0—10 B. Der mittlere Fehler der obigen Gleichung beträgt ±0·65 cm./sek., während die grösste Abweichung für 7 B gleich 1·4 cm./sek. ist. Sowohl die beobachteten wie die berechneten Stromgeschwindigkeiten vertreten nur Mittelwerte, die ohne Rücksicht auf den charakteristischen Strom gebildet worden sind. Der Strom hat nämlich sicher in der Richtung, wo er durch den charakteristischen Strom verstärkt wird, eine grössere Geschwindigkeit als in der entgegengesetzten Richtung. Bei der Anwendung eines reichlicheren Materials werden jedoch ohne Zweifel die verschiedenartigen störenden Einflüsse ausgeglichen.

Schwieriger ist dagegen die Aufgabe, eine Beziehung zwischen Wind- und Stromgeschwindigkeit zu erhalten, falls die letztere als der

arithmetische Mittelwert der den verschiedenen Windrichtungen entsprechenden Stromvektoren gewählt wird. Nach der Ekman'schen Stromtheorie[5]), die durch die Untersuchungen von Palmén annähernd bestätigt wurde, ist die Beziehung zwischen Wind- und Stromgeschwindigkeit linear. Dagegen hat Witting[6]) bei der Untersuchung einer grossen Anzahl gleichzeitiger Wind- und Oberflächenstrombeobachtungen gefunden, dass bei einer Windstärke, die kleiner oder höchstens gleich 5 B ist, die Stromgeschwindigkeit der Quadratwurzel der Windstärke und Windgeschwindigkeit beinahe proportional ist, wächst jedoch vielleicht noch langsamer als diese. Auch Thorade[7]) hat eine lineare Beziehung zwischen Stromgeschwindigkeit und Quadratwurzel der Windgeschwindigkeit hergeleitet, welche jedoch nur für kleinere Windstärken (bis 3 B) gilt. Bei stärkeren Winden ist dagegen nach Thorade die Stromgeschwindigkeit derjenigen des Windes proportional. In diesem Zusammenhang wollen wir noch erwähnen, dass Palmén[8]) für Äransgrund und Nahkiainen eine Beziehung zwischen Windstärke und Stromgeschwindigkeit erwartet, die von der Natur

$$y = ax^2 + b$$

ist, entscheidet sich doch nach der Reduktion der Beaufortzahl in m./sek. für eine konstante Proportionalität zwischen Wind- und Stromgeschwindigkeit.

In Tab. 10 geben wir das Verhältnis zwischen Strom- und Windgeschwindigkeit wieder. Aus dieser Tabelle geht hervor, dass das

Tabelle 10.

Verhältnis zwischen Strom- und Windgeschwindigkeit.

Windgeschwindigkeit (x)			Stromgeschwindigkeit (y)	$10^2\, y/x$	
Beaufort	Int. Skala	Köppen		Int. Skala	Köppen
	m./sek.	m./sek.			
1	1·2	1·7	1·9	1·59	1·12
2	2·6	3·1	2·9	1·12	0·94
3	4·3	4·8	3·9	0·91	0·81
4	6·4	6·7	7·5	1·17	1·12
5	8·6	8·8	11·5	1·34	1·31
6	11·4	10·7	16·0	1·40	1·50
7	13·9	12·9	15·9	1·16	1·23
8	16·9	15·4	21·9	1·30	1·42
9	19·9	18·0	27·5	1·38	1·53
			Mittel	1·26	1·22

[5]) V. Walfrid Ekman. On the Influence on the Earth's Rotation on Ocean Currents. Arkiv f. Matematik, Astronomi och Fysik. Bd. II, No. 11. Stockholm, 1905.

[6]) Rolf Witting. Zur Kenntnis des vom Winde erzeugten Oberflächenstromes. Ann. der Hydrogr. und Marit. Meteorol., XXXVII, Hft. V. Berlin, 1909.

[7]) H. Thorade. Die Geschwindigkeit von Triftströmungen und die Ekman'sche Theorie. Ann. der Hydrogr. und Marit. Meteorol., XXXXII, Hft. VII. Berlin, 1914.

[8]) E. Palmén. Ein Beitrag zur Berechnung der Strömungen in einem begrenzten und geschichteten Meere. Rapp. et Proc.-Verb. LXIV. Copenhague, 1930.

betreffende Verhältnis sowohl bei der Benutzung der internationalen als auch der K ö p p e n'schen Skala sehr grosse Schwankungen aufweist. Dagegen sind die Mittelwerte fast identisch mit denjenigen, die P a l m é n für Finngrundet erhalten hat, nämlich 1·27 inbetreff der internationalen und 1·23 für die K ö p p e n'sche Skala. Dieses Resultat ist besonders interessant wenn wir bedenken, dass die beiden Feuerschiffe, obwohl ihre Lage recht verschieden ist, sich in demselben Meeresgebiet, d.h. in der Bottensee, befinden.

Der Zusammenhang zwischen Windstärke und Stromgeschwindigkeit geht sehr deutlich hervor, falls wir die arithmetischen Mittelwerte für die verschiedenen Monate berechnen. Die Ergebnisse sind in Tab. 11 wiedergegeben, die auf eine bedeutende Übereinstimmung hindeutet. Zwar weichen die Eintrittszeiten der extremen Werte etwas voneinander ab. Dagegen beobachten wir eine der Windstärke entsprechende Abnahme der Stromgeschwindigkeit im November und eine

Tabelle 11.

Jährlicher Gang der Windstärke (Beaufort) und Stromgeschwindigkeit (cm./sek.).

Monat	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Wind	3·5	3·5	2·7	2·4	2·1	2·0	2·3	2·6	2·9	3·6	3·3	3·6
Strom 0 m. ..	11·2	10·9	7·3	5·8	4·9	6·8	7·9	8·0	9·1	10·6	9·1	10·6
15 m. ..	10·1	10·0	5·9	5·0	4·0	5·2	5·6	6·4	7·6	9·3	8·0	9·4
30 m. ..	9·3	9·6	5·5	4·7	3·7	4·3	4·4	5·4	6·7	8·8	7·3	8·7

gewisse mittlere Unveränderlichkeit der beiden im Januar und Februar. Eine Korrelationsrechnung [9]) für den jährlichen Gang der Windstärke und Oberflächenstromgeschwindigkeit ergibt den Korrelationsfaktor

$$r = 0{\cdot}917.$$

Da der entsprechende wahrscheinliche Fehler $s = 0{\cdot}032$ beträgt, erhalten wir für das Verhältnis r/s den Wert 29, was eine gute Korrelation besagt. Eine noch bessere Korrelation würden wir zwar für Windstärke und Stromgeschwindigkeit in der Tiefe erhalten. Da aber inbetreff dieser noch andere Faktoren, vor allem die Dichteveränderungen, hinzutreten, wollen wir diese etwas näher ermitteln.

Nach Tab. 11 ist die grösste Abnahme der Stromgeschwindigkeit von Oberfläche bis 30 m. Tiefe in der Zeit Juni bis September zu beobachten, somit gleichzeitig mit der grössten Temperaturabnahme gegen den Boden, die wiederum eine starke Dichtezunahme bedingt. Die letzterwähnte haben wir auf Grund des teilweise interpolierten und ausgeglichenen thalassologischen Beobachtungsmaterials bei Storbrotten aus den Jahren 1926—1935 berechnet. Für die Geschwindigkeitsabnahme und gleichzeitige Dichtezunahme ergibt sich der Korrelationsfaktor $r = 0{\cdot}811$ mit einem mittleren Fehler $s = 0{\cdot}067$, was dem

[9]) Nach O s c. V. J o h a n s s o n. Smärre förenklingar vid korrelationsberäkning jämte tillämpning på några meteorologiska exempel. Öfversigt af Finska Vetensk.-Soc. Förh. Bd. LVIII, 1915—1916. Afd. A. No. 29. Helsingfors, 1916.

Verhältnis $r/s = 12$ entspricht, somit ein sehr befriedigendes Resultat.

In diesem Zusammenhang wollen wir schliesslich mit einigen Worten die Ablenkung der Stromrichtung von der Windrichtung berühren. Die in Tab. 7 zusammengestellten reduzierten Stromvektoren geben für die verschiedenen Windrichtungen die folgenden mittleren Ablenkungswinkel:

N.	NE.	E.	SE.	S.	SW.	W.	NW.
15°	7°	11°	17°	4°	2°	19°	21°

Diese Werte besagen, dass die Ablenkung etwa in der Richtung der grossen Achse der Ellipse am grössten, in der senkrechten Richtung am kleinsten ist.

Was dagegen die Beziehung zwischen Windstärke und Ablenkungswinkel betrifft, so erhalten wir folgende Mittelwerte:

1B	2B	3B	4B	5B	6B	7B	8B	9B
23°	14°	2°	3°	12°	13°	19°	10°	12°

Wir beobachten, dass für die kleinsten Windstärken die Stromgeschwindigkeit mit wachsender Beaufortzahl abnimmt, dass dagegen inbetreff der grösseren Windstärken keine Regelmässigkeiten vorkommen.

Über quantitative Seihmethoden in der Planktonforschung.

Von

Ernst Hentschel.

VOR nunmehr 36 Jahren hat Lohmann mit grosser Sorgfalt den Nachweis geführt, dass selbst die feinsten Planktonnetze nicht im Stande sind, das feinste Plankton zu fangen. Diese Erkenntnis hat Steemann Nielsen[1]) jetzt auf Grund einiger eigener Beobachtungen neu vorgetragen. Lohmann zog aus seinen Erfahrungen den Schluss, dass man, um den vollständigen Gehalt des Meeres an Plankton quantitativ festzustellen, verschiedene Methoden für die verschiedenen Grössenordnungen anwenden müsse, Netzmethoden und Sedimentiermethoden. Nach Steemann Nielsens Meinung wird man durch Netzmethoden "leicht zu ganz falschen Vorstellungen über das Phytoplankton" geführt. Man müsse nämlich annehmen, dass die Forscher, welche sie anwenden, "glauben, dass die Netzfänge jedenfalls repräsentative Werte für die Phytoplanktonmengen geben".

Muss man das wirklich annehmen? Muss man das z.B. von mir und meinem Schüler F. Gudmundsson annehmen, mit denen sich der betreffende Aufsatz hauptsächlich beschäftigt? Ist es denkbar dass ich, der ich mehr Nannoplanktonzählungen durchgeführt habe als irgend ein lebender Planktonforscher, ganz vergessen haben sollte, von wie grosser und selbständiger Bedeutung das Nannoplankton im Meere ist?

Steemann Nielsen stellt, um die Unbrauchbarkeit quantitativer Netzfänge zu erweisen, für eine Anzahl "wichtigerer Arten" die Ergebnisse von Zählungen nach Netzfängen und nach dem Utermöhl'schen Mikroskop einander gegenüber. Es ist schade, dass er dabei nicht die anerkannt wichtigste Art des nordischen Nannoplanktons, *Pontosphaera huxleyi* mit berücksichtigt hat. An keiner würde sich so gut wie an dieser zeigen lassen, wie sinnlos es wäre, mit Netzmethoden den vollständigen Gehalt des Meeres an Phytoplankton

[1]) Steemann Nielsen, E., 1938. Über die Anwendung von Netzfängen bei quantitativen Phytoplanktonuntersuchungen. Journ. du Conseil, Bd. XIII, S. 197.

bestimmen zu wollen. Aber es hätte sich auch an keiner anderen so gut zeigen lassen, wie verfehlt die Angriffe gegen die Seihmethoden von hier aus sind, da diese mit *Pontosphaera huxleyi* eben absolut nichts zu tun haben. Bei quantitativen Untersuchungen mit Netz oder Sieb ist diese "wichtigste Art" die denkbar unwichtigste.

Steemann Nielsen vergleicht den Fang eines Planktonnetzes von der Maschenweite 50 μ mit dem eines Fischnetzes von der Maschenweite 50 cm. und behauptet, dass dies zwei einander ähnliche Methoden seien. Ein sehr sonderbarer Vergleich, denn mit einem solchen Planktonnetz wird so gut wie überall reichlich Phytoplankton gefangen, mit jenem Fischnetz aber so gut wie nirgends ein Fisch.

Der Aufsatz von Steemann Nielsen enthält also recht bedenkliche Entstellungen und Verzerrungen der Sachlage.

Wenn man sich ein Urteil über den Wert einer Methodik bilden will, so wird man sich doch wohl zunächst einmal klarmachen müssen, was diese Methodik bezweckt, und wird diesen Zielpunkt in den Mittelpunkt der Betrachtungen stellen müssen. Steemann Nielsen erwähnt gegen den Schluss seines Aufsatzes ganz nebenbei und ganz einseitig geographische Untersuchungen über das Plankton, und dass "quantitative Bearbeitung hierbei oft zweckmässig" sei. Nun, ich habe mir umfassende geographische Aufgaben gestellt. Ich bin damit beschäftigt, für umfangreiche Meeresgebiete Planktonkarten herzustellen, die auf Isolinien und damit auf Zahlenwerte gegründet sind, und das nicht nur für einzelne besonders geeignete Arten, sondern, so weit es möglich ist, für das gesamte Plankton einer bestimmten Grössenordnung.

Steemann Nielsen prüft meine Methodik nicht unter dem Gesichtspunkt, ob sie für diese meine Zwecke geeignet sei, sondern unter dem, ob Aufgaben, wie er sie sich gestellt hat, Untersuchungen über die Produktivität des Meeres, damit ausführbar seien. Er fragt sich, ob eine Seihmethode die Beurteilung des "vollständigen Gehalts des Meeres an Plankton" (so drückte einst Lohmann die Frage aus) ermögliche. Hätte er mich danach gefragt, ich würde geantwortet haben: Nimmermehr. Er behandelt nun aber diese Methodik so, als müsste er uns belehren, dass sie für jenes von ihm gesetzte Ziel unbrauchbar sei. Es handelt sich also um eine Herabsetzung dieser Methodik, indem ihr Zwecke untergeschoben werden, die sie gar nicht hat oder haben kann.

Ich habe gelegentlich die Gründe angegeben, weswegen ich neuerdings von den Sedimentiermethoden wieder abgegangen und zu einer Seihmethode (zur Benutzung kleiner Planktonsiebe) zurückgekehrt bin. Einer der wesentlichsten dieser Gründe ist der, dass ich unter den verschiedenen Methoden eine solche auswählen wollte, die einigermassen das Plankton in seinen beiden Hauptbestandteilen, Tierplankton und Pflanzenplankton, gleichmässig erfasste. Ich gehe dabei von der Vorstellung aus, *dass es zwei Hauptlebensweisen gibt*, die tierische und die pflanzliche und dass es wünschenswert ist zu erfahren, wie diese beiden Hauptlebensweisen sich zu den vom Meere dargebotenen Lebensbedingungen an den verschiedenen Orten und zu den verschiedenen Zeiten

verhalten. Gibt es eine Sorte Plankton, die über Pflanzen und Tiere einigermassen gleichmässig Auskunft gibt, so kann sie *in diesem Sinne* als besonders repräsentativ für das Plankton überhaupt gelten.

Da nun das Pflanzenplankton im allgemeinen kleiner, das Tierplankton grösser ist, so ist die Wahl der Methode hier eine Grössenordnungsfrage. Abgesehen von den Protozoen ist das kleinste Plankton rein pflanzlich, das grösste rein tierisch, mit Zunahme der Grösse aber findet ein allmählicher Übergang vom einen zum anderen statt. Daraus muss man folgern, dass es eine Grössenordnung gibt, in der sich beide ungefähr das Gleichgewicht halten. Es würde sich also theoretisch darum handeln, diejenige Methode herauszufinden, welche im Mittel ebensoviel tierische wie pflanzliche Individuen beschafft. Wenn ich beispielsweise in einem Fang 500 Tiere und 500 Pflanzenzellen habe, so gehört er dieser Grössenordnung an.

Untersucht man, ein wie grosser *Prozentsatz* einerseits der Pflanzen insgesamt, andererseits der Metazoen insgesamt auf diese Weise erfasst wird, so wird man zu dem Schluss kommen, dass von den Tieren ein sehr hoher Prozentsatz, von den Pflanzen nur ein sehr niedriger erfasst wird. Man kann also von den betreffenden Fängen aus mit ziemlicher Sicherheit auf die Gesamtmenge der Metazoen schliessen, durchaus aber nicht auf die Gesamtmenge der Pflanzen. Es ist selbstverständlich, dass man mit dieser Methode in die Gesamtmenge der Pflanzen nur sehr wenig tief hinabdringt. Darauf aber kommt es hier auch gar nicht an, sondern es handelt sich darum, in die Pflanzenbevölkerung ungefähr ebenso weit (besser allerdings etwas weiter) vorzudringen, wie in die Tierbevölkerung, und zwar nicht prozentual, sondern absolut.

Stellt nun eine derartige Methode die betreffende Grössenordnung "richtig" dar? — Wenn wir von möglichen technischen Fehlern absehen, so ist rein methodisch darüber folgendes zu sagen. Die Grössenordnung der Organismen des Fanges wird durch zwei Grenzwerte bestimmt. Der eine ist die Maschenweite, bei meiner Siebmethode 40 μ, der andere die Menge des durchgeseihten Wassers, bei meinen Arbeiten gewöhnlich 5 Liter. Es gibt immer eine Anzahl Organismen, die unter den so bestimmten Bedingungen "richtig", d.h. *vollständig und in genügender Menge* gefangen werden. Sie bilden den wertvollsten Teil des Fanges. Eine Anzahl anderer aber wird mehr oder weniger mangelhaft gefangen, teils weil die Wassermenge für sie zu klein, teils weil die Maschenweite für sie zu gross ist. Bei den ersteren, zu denen die grösseren, selteneren Arten gehören, ist die wahre Menge im Meer nur schlecht nach solchen Fängen zu beurteilen. Von den letzteren aber werden viele in grosser Zahl gefangen. Es fragt sich, ob und wie die betreffenden Zahlen verwertbar sind. Jedenfalls können sie nicht ebenso hoch bewertet werden, wie die Werte derjenigen Arten, die "vollständig und in genügender Menge" gefangen werden.

Man denke sich beispielsweise einen stabförmigen Organismus, dessen Querschnitt kleiner ist als die Maschenweite. Er wird, wenn er senkrecht auf eine Masche trifft, hindurchgleiten, in den meisten anderen Fällen aber zurückgehalten werden. So wird also, wenn der Fang

eine bestimmte Zeit lang an der Siebfläche umhergestrudelt wird, ein gewisser Prozentsatz der Individuen dieser Art gefangen werden, der Rest aber verloren gehen. Ist nun mit diesem Prozentsatz etwas anzufangen? Wenn man immer die gleichen Geräte in gleicher Weise benutzt, so dürfte der Fang der Wahrscheinlichkeit nach in einem einigermassen konstanten Verhältnis zu dem wirklichen Bestand stehen. Es werden also Relativwerte entstehen, die als solche mehr oder weniger richtig sind, insbesondere wenn man sie nur grössenordnungsmässig verwertet. Jedenfalls ist anzunehmen, dass, wenn solche Werte deutlich Gebietsunterschiede zu Tage fördern, diese wirklich in der Natur begründet sind. Das geographische Bild ihrer Verteilung wird dann eine mehr oder weniger brauchbare "*Annäherung*" an die Wirklichkeit darstellen.

Noch andere Gesichtspunkte der Beurteilung kommen zur Geltung, wenn die Untersuchung sich nicht auf einzelne Arten, d.h. auf ein mehr oder weniger homogenes Material beschränkt, sondern sich auf zusammengesetzte Formengruppen, etwa die Tintinnen, die Peridineen, die Diatomeen "mit dem Grössenindex 40 μ"(!) bezieht. Ich habe schon im "Meteor"-Werk darauf aufmerksam gemacht, dass zusammengesetzte Planktonbestände oft einen besseren Ausdruck für die Lebensbedingungen geben als einzelne Arten, weil in ihnen das Spezifische der einzelnen Arten mehr oder weniger durch das allen Gemeinsame verdeckt wird. Bei den Seihmethoden ist es ferner vielleicht von Vorteil, dass die oft massenhaft auftretenden ganz kleinen Arten, die in den Sedimentierproben das Bild oft zahlenmässig stark beherrschen, während sie doch volumenmässig von geringer Bedeutung sind, hier ausgeschaltet werden. Jedenfalls macht man immer wieder die Erfahrung, dass solche Gruppenwerte in ihrer geographischen Anordnung oft hervorragend sinnvoll erscheinen. Das kommt nämlich häufig darin zum Ausdruck, dass die betreffenden Planktondarstellungen eine unverkennbare Regelmässigkeit und Stetigkeit zeigen und sich zu den hydrographischen Verhältnissen in deutliche, überzeugende Beziehungen setzen lassen.

Es ergibt sich also, teilweise aus den technischen Bedingungen der Methode, teilweise aus den Erfahrungen, welche man mit ihren Ergebnissen macht, *dass sie, mit angemessener Kritik verwendet, ein richtiges Urteil über die Planktonbestände derjenigen Grössenordnung vermittelt, für die sie bestimmt ist.*

Steemann Nielsen sagt gegen den Schluss seiner Arbeit "Es ist nach meiner Meinung wertvoller, wenige Untersuchungen zu machen, die aber den Forderungen an Exaktheit so weit wie möglich entsprechen, als extensive Untersuchungen zu machen, bei denen dies nicht der Fall ist." — Was wertvoller ist, hängt wohl von dem Zweck ab, den man verfolgt. Ich möchte glauben, dass es für die vorwiegend fischereibiologischen Bestrebungen der Internationalen Meeresforschung zunächst wertvoller ist, extensive Darstellungen der Planktonverteilung in ihrem Arbeitsgebiet zu erhalten, auch auf die Gefahr hin, dass sie an Exaktheit einstweilen zu wünschen übrig lassen. Ich möchte dem

Begriff der *"Exaktheit"* den der *"Annäherung"* gegenüberstellen. Die ältesten Karten des Golfstromes waren gewiss nicht exakt, aber höchst wertvoll für ihre Zeit. Heute, anderthalb Jahrhunderte später, sind wir vielleicht berechtigt, von exakten Untersuchungen des Golfstromes zu sprechen. Ihnen ging eine lange Reihe ganz unentbehrlicher Annäherungsdarstellungen voraus. Es ist anzunehmen, dass auch die Geschichte der Planktonkarten ähnlich verlaufen wird.

Da aber Steemann Nielsen so grossen Wert auf Exaktheit legt, möchte ich hier noch die Frage stellen, ob denn das vielgerühmte Utermöhl'sche Mikroskop wirklich so exakt arbeitet. Hervorragende Planktonforscher sind der Meinung, dass viele Gymnodinien sich überhaupt nicht konservieren lassen. Ist das der Fall, so können mit dieser Methode über eine der wichtigsten Gruppen des Nannoplanktons keine richtigen Zahlen gewonnen werden.

Summary.

Steemann Nielsen's objection to the employment of samples taken by net, or other forms of strainer, for quantitative estimation of phytoplankton cannot be upheld, the argument being that his criticism springs from an erroneous conception of the aim of these methods.

Some Aspects of Integration in Plankton Communities.

By

C. E. Lucas,

University College of Hull, Oceanographic Laboratory, Leith.

RECENTLY two alternative theories concerning the relationships of phyto- and zooplankton have been put forward, one by Professor Hardy (1935) and the other by Dr. Harvey (1934). The former presented information collected during the "Discovery" Expedition (1925—27), which extended and confirmed the earlier observations of Pearcey (1885) suggesting an avoidance of dense areas of phytoplankton by zooplanktonts. Harvey's explanation, based upon examination of English Channel flora and fauna in 1933, suggested that rather similar phenomena might be due to the grazing effects of zooplanktonts upon the stocks of phytoplankton[1]). In 1934 and 1936, on the invitation of Professor Hardy, I was able to make some preliminary laboratory experiments on the relationships between these two groups, obtaining evidence which was by no means incompatible with the "exclusion" hypothesis, and also some data regarding the extensive predatory abilities of the zooplankton when well supplied with food (Lucas, 1936). During the early stages of this work I became particularly interested in the possible explanation of what might be termed "non-predatory" interrelationships within the plankton. This paper is an attempt to gather together some of the evidence from various fields in order to demonstrate the probable existence of such relationships and to show their importance in application to the problems of plankton ecology in particular and to ecology in general. Such a summary must, in this early stage, be tentative, but whilst I hope to be able to investigate these problems further by experiments specially designed with this objective, there seems reason to review now the evidence for the ideas put forward. This is done in the hope that it will draw attention to aspects of marine ecology which have not received much attention and will draw the comments

[1]) Castracane (1885) put forward a similar suggestion to explain the scarcity of zooplankton amongst dense phytoplankton.

of those whose greater experience may permit the amplification, modification, or even the rejection of the suggestions. However this may be, I should like to acknowledge here my indebtedness for the stimulating experience of being in the same department at the time when Professor Hardy was working on the Principle of Animal Exclusion, and also for his kindness in discussing with me the typescript of this paper.

The theories put forward by Harvey and Hardy[2]), as both writers have emphasized, are by no means incompatible, but whilst the former is in accordance with a now familiar line of investigation, the latter introduces some form of relationship which, it was admitted, was by no means understood, although possible factors were put forward amongst which were pH and the oxygen supply. In so far as they were conclusive the experiments of Lucas (1936) suggested that under various conditions zooplanktonts tended to avoid the associated conditions of light and actively photosynthetic phytoplankton: it remained necessary to isolate these factors, if possible, although it was suggested that the processes involved would likely be the result of the interactions of a number of factors. However this may be, the metabolisms of the organisms themselves have been postulated by both writers and it may be profitable to review some of the evidence elsewhere regarding such relationships.

In the general study of the organism in relation to its environment the physical effects were among the first to be considered, and it was only later that, along with observations on feeding, the organic effects came into prominence. Our knowledge of food-chains has led to a better appreciation of biodynamics and has made clearer the great intricacy of the network of biological relationships (see, e.g., Elton, 1928) but if we should tend to see here a sufficient "cause", combined with physical factors, to account for the fluctuating balance of the community we must first consider the accumulating evidence regarding yet other forms of relationship. Elton (1928) has admitted the possibility of other biological relationships whilst considering them as yet too complicated for analysis. In the field of marine biology Herdman (1924) has hinted at the possible importance of such factors, and more recently Russell (1936) in his important review of different aspects of zooplankton research quotes Bigelow (1931) with approval, as follows:— "As yet we know little of the interrelationships of different species or groups of animals in the sea beyond the obvious fact that some prey on others, but we may be certain that in many cases interrelationships of less obvious sorts are vital links in the animal economy". Perhaps even more significant are the words of Johnstone, Scott and Chadwick (1924): "Also we are pretty sure that the plankton communities influence each other — that there are what we may call group symbioses on the great scale so that the kind of plankton which we may expect to be present in

[2]) Nielsen (1936) has put forward other (and more physical) suggestions regarding the relationships of planktonic animals and plants.

a certain sea-area must depend, to some extent, on the kind of plankton which was previously present."

It should not now be necessary to stress that organisms may live in very different ways in different conditions, although writers do not always discuss communities as if this were fully realized. Russell (1936) saw need to emphasize this point when pleading for a more detailed study of the biology of the different species. The possibility that the varying habits (e.g., of *Calanus finmarchicus* in its different seasonal broods and in different areas) might be due in part to the varying organic environment does not appear to have been fully explored, but if we consider pelagic communities from this aspect it becomes even more evident that they are continually changing than it is on the land. As in any stretch of water the diatom community progresses each spring from one stage in the succession to the next, any copepods which are feeding on the first members of this series must, as the food dies, do one of three things — either find other food, cease feeding, or migrate into other waters in order to find the original type of food. Sooner or later this last will become impossible and one of the others must be adopted. These are changes of the type made clear by Elton in other fields, and in plankton studies various workers have touched upon their significance in relation to the food supplies of the various herbivores and other animals. But is it not also likely that the animal may be subject to other influences as it lives through the various stages of the developing environment (and for all their possible migrations they cannot avoid some very significant changes)? The phytoplankton species inhabit a similarly changing organic environment (including changes in the numbers of their own and other species and also in the numbers of the associated animals), yet can we be sure that in the course of these changes the only influences are those associated with food (competition for nutrient salts and the attacks of herbivores etc.)? These are questions which cannot easily be answered except by observation and experiment, but there is now an extensive accumulation of evidence from work in other fields which is relevant to this point and which suggests adequate reason for such investigations. I refer to the vast number of experiments regarding single organisms and groups of them suggesting in one way or another the existence of biological processes which would not normally be considered as representative of the prey-and-predator relationship. Here it will only be possible to select arbitrarily a few observations and experiments from the many suggesting the processes in mind. For further evidence the reader must be referred to the original papers and the excellent reviews by Allee (1931 and 1934) who has surveyed this literature almost exhaustively in his discussion of the survival value of community formation. As he has shown, the study of "animal aggregations" is of great interest in consideration of the origin of social development — the ability to form societies or communities of even the lowest grades demands a tolerance of other members and other species which must have had evolutionary significance. But however

social organization may have originated, we are here more concerned with its maintenance, variability and integration. Whilst Professor Allee was undoubtedly conscious of the value of this evidence to ecology, his major interest[3]) may have prevented his stressing this aspect, although a fuller realization of it seems essential to the ecologist.

The following evidence[4]) is presented for consideration:—

(1) In his experiments on the growth of plant tissues Haberlandt (1919 and later) found that isolated tissues would grow although their cells would not divide; larger pieces of tissue would give rise to cell divisions and he associated this with the production by the tissues of "wound" or division hormones. We may also note the comment of Harrison (1928) on animal tissues to the effect that "single somatic cells isolated in culture media do not proliferate". Whilst more recent work on animal tissues has shown that the problem is more complicated than was perhaps originally thought (tissue-volume ratios are seen to be of importance) it seems still probable that maximal growth may be obtained from non-minimal size of explants.

(2) Churchman (1920) found that whilst innoculation with one cell of *B. coli* into gentian violet broth produced no growth, yet the use of twenty cells would show quite a good growth. Later experiments showed that this still applied when the proportionality of the volumes was maintained constant in the two experiments and he was led to suggest that some "communal activity" of the bacteria existed.

(3) Robertson (1921 and later) observed that in limited amounts of culture fluid two Paramoecia would show a faster division rate than would one, and he suggested some allelocatalytic effect. Petersen (1929), in repeating Robertson's experiments, found that the organism-volume ratio was of importance here and that the results could be controlled according to the volume of the fluid which was used. More recent work still has taken into consideration the density and volume of the bacterial content of the cultures, and whilst Robertson's observations are confirmed in essentials it now seems probable that the effect is due to the relative numbers of the bacteria, there being an optimal density for the most rapid reproductive rate of the protozoan.

(4) Chapman's studies of the population growth of the flour beetle (1928) are well known and Allee (1931) has observed that the maximal initial rate of increase is at a medium density of innoculation rather than the lowest or the higher ones. Park (1932) has confirmed this and shown it to be probable that the factors at work concern the egg-eating of the adults, which will be greatest at denser seedings, and the copulation-rate which is also greater at denser populations, the two factors working in opposition.

[3]) "The whole range of mass physiology has been presented with the thought that it forms a large part of the background for social life." (Allee, 1934)

[4]) The greater number of the experiments are to be found in Allee's reviews, together with an extensive bibliography.

(5) The experiments above have been selected as examples of the intricate factors which appear to be at work in the initiation of a population. All illustrate in one way or another the reciprocal effects of one organism upon another (or of parts of organisms). In the later growth of populations under experimental control, there is good reason to believe in similar interrelationships, various examples of growth-curves providing examples. An initially slow rate of increase is followed by an increasingly rapid one and then a state of decreasing growth-rate is followed by decrease in the actual numbers or a constant population according to the various conditions. Although much of the evidence is confused there is a general tendency to believe that in the growth of yeast, for example, there is some substance ("bios") which is produced by the cells and which tends to increase the rate of growth of the cultures. Comparable with such a finding are the results of various workers regarding the production of "auximones" which stimulate the growth of plants in cultures, though whether these substances are essential to growth has been doubted by some. The later stage of decreasing reproduction has been associated with various factors which are by no means always due to an insufficient supply of food. Chapman (1928) found evidence of increasing cannibalism in the flour beetles, whilst Goldie (1931) and others have suggested the toxic effects of excretion in the growth of bacteria. Other workers have found signs of toxic effects arising from metabolism in cultures of protozoa.

(6) Of particular interest in these connexions are the observations of Gausse (1932) regarding the associated growth of two species of yeast. It ceases at a lower density than that of one of them alone, probably as a result of the greater alcohol production of the other one, although this may be present in fewer numbers.

(7) From consideration of the beneficial effects of numbers we have been led to consider some harmful ones (not necessarily at the same densities). A further number of these are so well known that they need no mention here. As described, the observations of "animal exclusion" form an interesting example showing interspecific effects, most of the other examples being intraspecific: Pickering (1917) noticed that the excretions of roots have toxic effects on the growth of associated plants whether of the same or other species.

(8) The most generally accepted explanation of succession in bacteria and protozoa involves similar factors, together with another. A typical series in protozoan cultures is Monad, Colpoda, Hypotrich, Paramoecium, Vorticella, and Amoeba, and the explanation suggests that as the population of one increases in the usual manner, it becomes more and more subject to the effects of its own metabolic activities which, by their toxicity, finally prevent increase and even cause the death or dormancy of the organisms. This activity, however, clearly modifies the environment (pH and other factors have been discussed) and it is thought that this occurs in a manner suited to the growth of the next in the series, that in turn preparing the way for another

stage, and so on. Whilst it is clear that the food supply may play a part here it seems improbable that it will be the major one.

(9) The evidence reviewed so far has concerned the normal growth and death of populations, but there remains another section of experiments dealing with interrelationships in other aspects of the lives of organisms. Saunders (1924) observed the swarming of *Spirostomum* in clusters on the bottom, in association with increased alkalinity due to photosynthesis of algae. Atkins, regarding the shoaling of herring (1922), points out that large numbers of fish will undoubtedly modify the pH of the environment, and it seems probable that the clusters of *Spirostomum* may do this also, thus modifying, in this example at least, the surroundings to their advantage (high pH values being lethal). Similarly Allee (1931) has commented at length on his observations of local modification of oxygen values within swarms of *Asellus*, whilst amongst others Darby (1924) has emphasized the buffering effects of organisms, tending to modify pH values towards the optimum.

(10) Amongst other examples it has been shown that grasshoppers are less harmed by lethal substances when massed in large numbers than when in smaller numbers.

(11) Carpenter (1927) found that when minnows were killed successively in solutions of lead nitrate (lethal) the length of life became progressively longer and she deduced that each fish diluted the poisonous solution by extracting the agent. Allee and his school (1934) have shown that groups of fish (goldfish) live longer in solutions of colloidal silver than do single fish.

(12) There is general conformity among different workers in finding a greater viability for sperm suspensions when in denser solutions, although many reasons have been put forward regarding the earlier death in the dilute suspensions.

(13) Robertson (1921) found that *Enchelys farcimen* invariably died when isolated in cultures at 30° C., but that groups of individuals were able to live apparently satisfactorily at this temperature.

(14) The findings of various observers have indicated that there is an optimum density at which growth of sea-urchin eggs is the greatest. Extracts of the eggs in alcohol and acetone have been found to inhibit growth.

(15) In addition to the observations of Hardy, in some preliminary experiments Lucas (1936) observed that both mysids and copepods lived longest when in intermediate densities of diatom cultures, the very dense as well as the sterile and weaker cultures causing early death.

(16) Another aspect of the interrelation between organisms is seen in the work of Castellani (1926) (amongst others of a similar character) who found that *B. morgani* (which when alone produces no gases or acids in cultures of mannitol, sorbite, or maltose) in association with *B. typhosus* developed gaseous products, although the latter alone produces a characteristic acidity.

(17) Johnstone, Scott and Chadwick (1924) pointed out

that "some bacteria are incapable of producing their typical effects (say of producing and fixing elementary nitrogen from its solution in sea water) if they are present in pure culture. In order to function effectively they must be in association with some organism which, by itself, cannot produce the effect in question".

(18) The well-known experiments of U v a r o v and others suggest very strongly that the organic surroundings of locusts (i.e., the presence or absence of others of the species during development) influences their colour, shape, and habits in later life.

(19) The work of B a n t a and B r o w n has shown that crowding has the result of producing sexual eggs in Cladocera which under less crowded conditions produce parthenogenetic ones. Whilst the state of nutrition may play a part here there is reason to believe that the accumulation of metabolic products is of importance.

(20) In April 1938 Professor W e i s s published in the *Journal of the Royal Horticultural Society* a short note on "The influence of one plant on another", which is yet another sign of a growing interest in the problems dealt with here, and which has been particularly encouraging to the present writer in suggesting and confirming the importance of such relationships. One or two of these have already been quoted above; others show how the biological effects, on associated plants and their tissues, of products of ripening fruits, etc. may vary according to the concentrations involved. Some of the effects have been compared with those of heteroauxin.

(21) I can only briefly refer to embryological and genetical evidence here, but some mention may help to emphasize how widespread are processes which are fundamentally similar to those under discussion. They appear in the interaction between parts of the egg and of the embryo (need one mention also the egg and the spermatozoon?), whilst the recent introduction of the concept of the "dynamic field" stresses the similarity of life processes at this "level" to those at the "level" of ecology as usually understood. The concept of the gene-complex in genetics may serve to underline this at yet another biological "level".

(22) It seems relevant here to recall the various observations regarding symbiosis, providing essentially a study in ecological balance and integration between different organisms.

It may be thought that this is a very haphazard collection of examples, but from their various fields and view-points they are all remarkable in showing, under natural conditions and in the laboratory, the varied but definite modification of the lives of organisms (or parts of them) by their organic surroundings. A l l e e did not find it necessary to separate in his evidence observations regarding feeding from other types of relationship, and the examples given above include some in which competition for food may have played an important part, but the chief consideration will be given to showing how the non-feeding factors are equally important for our understanding of ecology. In the greater number of the examples (and hundreds more

dealing with representatives of all the great animal groups and many plants, with communities of the water, the air, and the land, but largely of the former) we can see important effects on the life of the individual which seem to be due in the simplest analysis to the varying numbers of the rest of the community, not less those of its own species than of others. The most carefully investigated cases suggest that under given conditions there are optimal densities both within and without the species for life and reproduction, both of which are more or less seriously disturbed when these optima are over-stepped on either side. Whilst the evidence points to the significance of the numbers or bulk of the life forms concerned, the actual processes whereby this factor is made effective are more debatable. In some general way the different results suggest processes which are perhaps best summarized in the words of A l l e e below — processes leading to the production of toxins, autocatalytic agents, products of autolysis, the more usual products of excretion and metabolism, and a number of others have been suggested. In addition we must bear in mind purely mechanical effects and the possible extraction of substances from the environment by one form, which may have appreciable effect upon its own life or that of another, although these may not be "foods" as usually considered. In almost all the examples the attainment of a certain, apparently intermediate, density has survival value for particular forms; other and associated forms may thrive most at this or other densities according to the circumstances. Whilst many of the suggested effects are specific, others are not so and there appear to be in addition a number of more generalized effects (see 9—13 above) which have communal value. They are shown most clearly for communities or associations under harmful conditions. If in some of the observations it is difficult to separate feeding from non-feeding effects, in others it is clear that the former are not sufficient to account for the reactions and, indeed, A l l e e has summed up as follows:— "Once formed, aggregations of aquatic organisms condition the medium surrounding them by the addition of secretions and excretions the nature and biological effect of which form one of the important problems of mass physiology".

Whilst it would be dangerous to draw analogies too close at this stage, it is yet tempting, in relation to the nature and suggested explanations of many of the observations under review, to think also of the increasing information regarding the action of vitamins, hormones, enzymes, etc. The well-known relationships between individuals of Bonellia, for example, although not usually considered from the ecological view-point provide yet another instance of organic reactions of the type considered here, and one which, moreover, it is possible to associate with the probable production *externally* of a hormone as usually understood.

It is suggested that here we have at least sufficient evidence from other fields to justify the suggestion that in pelagic ecology such relationships may play a very important part, and it is probable that

in "Animal Exclusion" we have a generalized example of this type of process since it is in the last analysis a series of observations regarding the varying numbers of organisms, with characteristic suggestions of optimum densities varying for different species, and apparently involving a factor other than the relationships of prey and predator. It is of particular interest that in this example both plants and animals should be included. If the actual mechanism is not clear at this stage we need not be surprised (there may well be more than one factor), although it seems reasonable to suggest that in part the active plants secrete into the water substances which are avoided by, or are even lethal (as experiments have suggested) to the animals[5]). On the other hand Wimpenny (1937), discussing the essentially related problem of the "inclusion" of eggs, larvae and spawning individuals, has associated it with the production of oxygen by the phytoplankton, meanwhile allowing that other metabolic effects should not be dismissed.

There are other processes in pelagic ecology which may have a partial explanation on these lines. The familiar phenomena of periodicity and succession provide a marked "exclusion" in time and, allowing for the close relations between time and space in hydrobiology, this may also be interpreted (and seen) as an exclusion in space. Normally certain characteristic maxima do not occur together, as has been noted, e.g., in the succession of various diatom species and between these and the dinoflagellates. These may be compared with the succession found in cultures of protozoa and bacteria — sequences which occur in nature also — the suggested explanations for which accord well with the association by Brandt (as early as 1896) of succession between the diatoms and dinoflagellates with their characteristically different metabolisms producing fats and carbohydrates respectively. With such different physiological processes they may well condition the environment, with subsequent effects not only to themselves but to others.

Reference may be made to another paper on this matter, one which does not seem to have received much notice from marine workers. Akehurst (1931) put forward the idea that periodicity and succession in the phytoplankton of ponds might be due to the production, by the different forms, of secretions which are ultimately toxic to themselves but act as "accessory food" substances for other forms. On the evidence of West and Fritsch (1927) he divided the species in a number of ponds into "oil", and "starch" groups, and found that in time and space they showed an alteration of abundance. Whether or not the suggestion regarding accessory food is the correct one, this provides further evidence of exclusion in time and space and one which undoubtedly suggests a modification of the surroundings by life processes, differing at least in part from the usual conception of the feeding cycle. May we not say that the evidence from periodicity

[5]) As yet we are ignorant largely of the possible secretions of pelagic forms (particularly the diatoms) although Gaarder and Gran (1927) have suggested that there are such secretions, that they must at times be extensive, and may be important in the economy of the sea.

and succession implies that, amongst other factors, the balance between successive cross-sections of the community may lie in the relations between varying numbers of organisms having more or less different physiological properties?

The processes of growth in the phytoplankton may be viewed afresh in this light. The classical results obtained by Allen (1914) on the culture of plankton diatoms suggested that there existed some substance in natural sea water which was necessary to the proper growth of the plants — something which was not available in artificial media[6]). His experiments strongly pointed to the possibility that this might be a product of living matter. The findings are not dissimilar from those of workers who found that a certain density of organisms per unit of medium was necessary for satisfactory development, with the implication and some evidence that the organisms secreted into the water substances necessary for further growth. It would be futile to consider the details at this stage, but since the appearance of Allen's paper a large amount of evidence has been produced to support his suggestion that in the early growth of some organisms at least the presence of products of previous or contemporary forms of life are essential to further growth[7]). The evidence from experiments on tissues, Protozoa, Bacteria, and some metazoans further implies that from this stage onwards the products of the cells' own activities may accelerate growth up to a point of maximal density but that then, apart from the supply of food which is available, the numbers of the species may gradually or rapidly disappear (as we see them do) from the results of their own activity. In natural conditions it may be difficult to distinguish this from the decreases due to "food" shortage or the depredations of herbivores. It is clear that a number of factors may play a part but there is good reason to think that these two are not sufficient to account for many of the decreases. If the major "food" salts are too scarce to permit the continued growth of an early form in the series, it is doubtful whether they will be abundant enough to permit the development of those forms, often much more numerous, which come later[8]). Here we must also consider the recent findings of Gardiner (1937) implying that after death the essential salts may be returned more quickly into circulation than has been usually thought probable. Again, if the zooplankton is so dense as to graze down an early form (usually the zooplanktonts are rare at this stage) then it seems even more likely that they will be able to prevent the flowering

---

[6]) That now by the use of "Erdschreiber" and similar preparations it is possible to obtain growth in otherwise artificial media need not show Allen to have been wrong. It seems significant that the essential constituent of this "growth" agent should be a normal soil which clearly has been also the container of life and biological products.

[7]) It may be significant that Allen noticed that the previous life of bacteria in the cultures was beneficial.

[8]) We have to allow for the possibility that the earlier forms may extract from the water the whole of rare salts essential for their growth, and that the disappearance of these may be essential to growth at a later stage in the succession.

of later forms which are at first very scarce in the plankton[9]). The results of research on "mass physiology", to adopt the term used by Allee, suggest strongly that the early activity of one form may so modify the environment as to make it suitable for a later one or ones, although how far this arises from the absence of the competition of the first form and how far from the more fundamental (and essential) modification of the environment (rendering it "adapted" to the requirements of later forms) we cannot yet say. The available evidence demands further study of non-predatory relationships and gives hope that thereby we may be able to solve important problems, thus obtaining a clearer knowledge of the close integration within the community.

Succession is a general characteristic of the plankton and reactions of the type postulated may be widespread although, bearing "animal exclusion" in mind, we shall realize that the activities of one form may not always be beneficial to others. Should such processes exist, the ecological network appears even more complex and, in considering the phytoplankton for example, we can see how the varying depredations of the herbivores might interact to disturb the suggested non-predatory processes.

Other aspects may also be important, as the experiments regarding the control of form, and even of sex, should imply, and the relevance of the work of Allee and his co-workers on "mass-protection" needs no emphasis. A further aspect has been discussed by Gran (1931), from a different point of view, in reviewing the problem of the stimuli originating diatom outbursts in the spring of each year off the coastal banks and over deeper waters, and in the interesting observations of intensive growth at the juncture of different bodies of water. In addition to the convincing suggestions put forward by him, the two problems also strongly suggest the relevance of such factors as I have been discussing, in that they concern the development of life within and at the juncture of different bodies of water (parts of the environment) — bodies which will have supported differing forms of life and which may have been differently conditioned thereby. In this connexion we may note that Hardy (1935, p. 86) has postulated "that the mixing of two different water systems, in providing a change of environment, is a cause of high productivity (provided, of course, that nutritive salts are present ....)". Whilst here, as with Calkins, who is cited, it is the more physical aspect of the modified surroundings which is considered, in another part of the same work (p. 359) Hardy has speculated upon another aspect of current systems and one which is more organic, i.e., the changes which may occur in water passing from regions of predominantly "free" phytoplankton to regions of "imprisoned" phytoplankton — from temperate regions to more tropical ones. That there are changes in the flora and fauna is undoubted and there seems good reason to believe that there may be associated "byeproduct" changes with the "aging" of the

[9]) I have occasionally observed that in early growth the feeding of animals may be great enough to prevent growth of diatoms in cultures although this must depend on the organ-volume relations (unpublished).

water — changes analogous to those thought to exist in the relatively stationary waters in which temporal succession has been observed. In the general study of marine biology in relation to current systems, there seems good reason to hope that the hypothesis of "biological conditioning" may prove a fruitful one.

To sum up, my wish has been to illustrate the probable importance of what I have termed "non-predatory" relationships in the ecology of the plankton and elsewhere, relationships which are revealed by the varying numbers of different members of the ecological complex and which may be the visible sign of an underlying and less obvious environmental factor which is no less important than the physical ones which have been so long investigated and those biological ones concerned with feeding within the more limited use of that term. The reader may feel that in this essay a number of well-known speculations by various oceanographers have merely been gathered together in the form of tenuous theory, but I have tried to show rather that these few speculations (in most cases put forward tentatively, or as secondary alternatives) may find significant support from work in other fields, fields in which similar problems and others not so similar at first sight have been investigated more thoroughly than has been possible in the short history of this science. In particular I wish to stress that the suggestions are not put forward with the view of replacing the more usual ideas of relations between the organism and the environment[10]), but to extend these to obtain a fuller realization of the importance of the organic surroundings, based upon the observation of processes appearing as a feature of most (perhaps all) forms of life. However correct some of the suggestions may be as applied to the problems of pelagic ecology, there appears to be little doubt of their importance regarding the fundamental biology of the community. From their various view-points they all point to an even greater degree of integration between the various organisms, and with the non-living environment, than is usually allowed — a degree of integration which should require us to see relationships in ecology (often appearing as correlations, although not necessarily so) not so much as the results of "cause" and "effect" but of processes occurring simultaneously and developing out of each other. This is a conception which has also its application in our understanding of the processes of development, as well in evolution as in embryology and in the life of the community. The biological integration so evident in embryology and, as I have tried to show, in ecology proper must also have played an important part in the early evolution of the forms of life — a part not less evident in the relationships (however tenuous) between the members of evolving species and between the then contemporary species themselves than, as A l l e e has shown, in the early stages of society formation and in the evolution of the individual.

[10]) One of the significant features of ecology is the increasing evidence (to be expected on theoretical grounds) of "multiple causality" — yet another sign of the dynamic integration apparently of the essence of communal life.

Bibliography.

Akehurst, S. C., (1931). Observations on Pond Life, with special reference to the possible causation of swarming of phytoplankton. Journ. Roy. Mic. Soc. L 1, 237—65.

Allee, W. C., (1931). Animal Aggregations. Univ. of Chicago Press.

Allee, W. C., (1934). Recent studies in mass physiology. Biol. Rev. Camb. Phil. Soc., IX, 1—48.

Allen, J. E., (1914). On the culture of the plankton diatom *Thalassiosira gravida* Cleve, in artificial sea-water. Journ. Mar. Biol. Assoc., N.S., X, 417—39.

Bigelow, H. B., (1931). Oceanography. The Riverside Press. Cambridge, Mass.

Brandt, K., (1896—8). Beiträge zur Kenntnis der chem. Zusammensetzung des Planktons. Wiss. Meeresuntersuch. Kiel. N.F., I—III.

Carpenter, K., (1927). The lethal action of soluble metallic salts on fishes. Brit. Journ. Exp. Biol., IV, 378—90.

*) Castellani, A., (1926). Journ. of Tropic. Med. and Hyg., XXIX, 217—26.

Castracane, A. F., (1885). Statement quoted in Narrative of the Cruise. Rep. Sci. Res. Voy. "Challenger", I, Part II, 931.

*) Chapman, R. N., (1928). The quantitative analysis of environmental factors. Ecology, IX, 111—23.

*) Churchman, J. W., (1920). Communal activity of bacteria. Proc. Soc. Exp. Biol. and Med., XVIII, 22—23.

Darby, H., (1924). Studies on Growth acceleration in protozoa and yeast. Brit. Journ. Exp. Biol., VII, 308.

Elton, C., (1927). Animal Ecology. Sidgewick and Jackson, London.

Gardiner, A., (1937). Phosphate Production in Planktonic Animals. Journ. du Conseil, XII, 144—6.

Gran, H. H., (1931). On the Conditions for the Production of Plankton in the Sea. Cons. Perm. Int. p. l'Explor. de la Mer. Rapp. et Proc.-Verb., LXXV, 37—46.

Gaarder, T., and Gran, H. H., (1927). Investigations on the Production of Plankton in the Oslo Fiord. Cons. Perm. Int. p. l'Explor. de la Mer. Rapp. et Proc.-Verb., XLII.

Gausse, G. F., (1932). Experimental Struggles on the Struggle for Existence. Brit. Journ. Exp. Biol., IX, 389—402.

*) Goldie, H., (1931). Absorption et destruction des substances inhibitrices de filtrats microbiens. C. R. Soc. Biol., CVIII, 762—4.

*) Haberlandt, G., (1919). Zur Physiologie der Zellteilung. Sitzungsber. Preuss. Akad. Wiss. Berlin, XX, 322—48.

Hardy, A. C., (in Hardy and Gunther, 1935). The Plankton of the S. Georgia whaling grounds and adjacent waters, 1926—27. Discovery Reports, XI.

Harvey, H. W., (1934). Annual variation of planktonic vegetation. Journ. Mar. Biol. Assoc., N.S., XIX, 775—92.

*) Harrison, R. G., (1928). On the status and significance of tissue culture. Arch. Exp. Zellforsch., VI, 4—27.

Herdman, W., (1924). Pioneers of Oceanography. Liverpool.

Johnstone, A., Scott, A., and Chadwick, H. C., (1924). The Marine Plankton. University Press of Liverpool.

Lucas, C. E., (1936). On certain interrelations between phytoplankton and zooplankton under experimental conditions. Journ. du Conseil, XI, 343—62.

Nielsen, E. S., (1937). On the Relation between Quantities of Phytoplankton and Zooplankton. Journ. du Conseil, XII, 147—54.

*) Park, T., (1932). Studies in population physiology. Ecology, XIII, 172—81.

Pearcey, F. G., (1885). Investigations of the movements and food of the herring and additions to the marine fauna of the Shetland Isles. Proc. Roy. Soc. Edin., VIII.

*) Petersen, W., (1929). The relation of density of population to rate of reproduction in *Paramoecium caudatum*. Physiol. Zool., 11, 221—54.

Pickering, S., (1917). The effect of one plant on another. Ann. Bot., XXXI, 183—87.

*) Robertson, T. B., (1921). Experimental studies on cellular multiplication. Biochem. Journ., XV, 595—611.

Russell, F. S., (1936). A Review of some Aspects of Zooplankton Research. Cons. Int. p. l'Explor. de la Mer. Rapp. et Proc.-Verb., XCV, 3—30.

Schreiber, E., (1927). Die Reinkultur von marinen Phytoplankton und deren Bedeutung für die Erforschung der Produktionsfähigkeit des Meereswassers. Wiss. Meeresuntersuch., N.F., X, 10, 1—34.

Weiss, F. E., (1938). Influence of one plant on another. Journ. Roy. Hort. Soc., LXIII, 166—69.

West, G. S., and Fritsch, F. E., (1927). British Freshwater Algae. London.

Wimpenny, R. S., (1937). The Distribution, Breeding and Feeding of some important Plankton Organisms of the South-West North Sea in 1934. Min. of Agric. and Fish., Fish. Invest., Ser. 11, Vol. XV, No. 3, pp. 1—53.

*) Some discussion of these, amongst other papers, will be found in Allee (1931 and 1934).

Diurnal Variation in the Feeding and Breeding of Zooplankton related to the Numerical Balance of the Zoo-Phytoplankton Community.

By

R. S. Wimpenny,
Fisheries Laboratory, Lowestoft.

A considerable literature on the diurnal movement of zooplankton and its special relation to light has been conveniently summarized by F. S. Russell [16]. The nightly rise to the surface of the herring is perhaps better known than that which is so common among the zooplankton, and Lucas [12] has shown that among herring a greater proportion of the smaller ones swim upwards each night. Diurnal vertical movement has even been ascribed to phytoplankton organisms by Hardy [6] who points out that the phytoplankton movement appeared to be upwards by day and down at night, or in the opposite sense to that made by zooplankton organisms.

Hardy [7] has also considered the relations of the animal and vegetable plankton and has shown that a number of zooplankton species are not found in areas dense in phytoplankton. He considers that they are excluded and that this exclusive effect limits their diurnal vertical movements and gives them a special horizontal distribution as a result of the different speed of flow shown by ocean currents at different depths. By this means the massing of plankton organisms is explained. Savage and Wimpenny [18] have, however, pointed out that the massing of both zooplankton and herring takes place on the edges of diatom patches in the southern North Sea where the diatoms extend from the top to the bottom and where it is not possible for zooplankton to be borne under the diatom mass. Hardy's views on the relation between zoo- and phyto-plankton have also evoked supplementary and alternative explanations from Harvey [9], Steemann Nielsen [19], and Wimpenny [20], and it is clear that a new and interesting ecological and physiological field is being opened to the oceanographer and fisheries expert.

Finally, in such investigations as those of Marshall, Nicholls and Orr [15] for *Calanus finmarchicus* and Jenkins [11] for *Coscinodiscus centralis*, there has been a tendency to deal with diurnal variation in the metabolism of special organisms in relation to light.

The present contribution is based on the observation that I have made elsewhere [20] in respect of the ease with which it is possible to determine the proportion of copepods containing food, and the

Table 1.

Cruise R, Station 28, 1935.
Lat. 53°46′N., Long. 2°20′E.
Hensen Net Hauls.

Time and Date	2030 27.XI	0230 28.XI	0530 28.XI	0830 28.XI	1130 28.XI	1230 28.XI	1430 27.XI	1730 27.XI
Biddulphia sinensis and *Rhizosolenia styliformis* (1,000s)	86·4	88·5	90·5	98·1	109·2	71·8	61·7	160·5
Paracalanus parvus ♀, % with food	100	83·3	94·4	77·8	77·8	83·3	61·1	80·0

Cruise O, Station 8, 1936.
Lat. 52°00′N., Long. 2°06′E.
Tow-nets at 0, 15, and 30 metres, and combined.

Time and Date	2005 7.X	2400 7—8.X	0420 8.X	0827 8.X	1220 8.X	1620 8.X
Biddulphia sinensis at all depths (1,000s)	2,130	816	4,821	5,922	2,595	5,268
Paracalanus parvus ♀						
at 0 m.	2,700	2,400	5,850	2,100	600	4,500
15 m.	5,550	2,250	6,600	5,100	3,300	4,050
30 m.	5,550	2,400	3,900	6,000	3,900	4,650
at all depths	13,800	7,050	16,350	13,200	7,800	13,200
% *Paracalanus parvus* ♀						
with food at 0 m.	83·3	100	100	100	100	96·7
15 m.	89·2	100	97·7	97·1[1]	95·5	92·6
30 m.	97·3	87·5	100	97·5	84·6	96·8
at all depths	91·3	95·7	99·1	97·7	90·4	95·5
Biddulphia per Paracalanus (all depths)	154	116	295	449	333	399

Cruise O, Station 39, 1936.
Lat. 53°32′N., Long. 1°05′E.
Tow-nets at or near 20 metres.

Time and Date	2035 15.X	0001 16.X	0315 16.X	0600 16.X
Rhizosolenia styliformis (1,000s) ..	25	1,158[1]	1,365	840
Paracalanus parvus ♀	4,500	18,750[1]	17,250	9,000
% with food	50·0	92·0[1]	65·2	41·7
Rhizosolenia per Paracalanus	6	62	79	93

[1]) at 18 metres.

positive relation between this proportion, and the density of phytoplankton where a wide area is considered. The preliminary results which follow are an application of the regional work to the problem of diurnal variation. I have also sought clues as to what degree the proportion of copepods feeding may be considered as a rate of assimilation and to what extent the phytoplankton crop is related to zooplankton grazing, reproduction, and its own division.

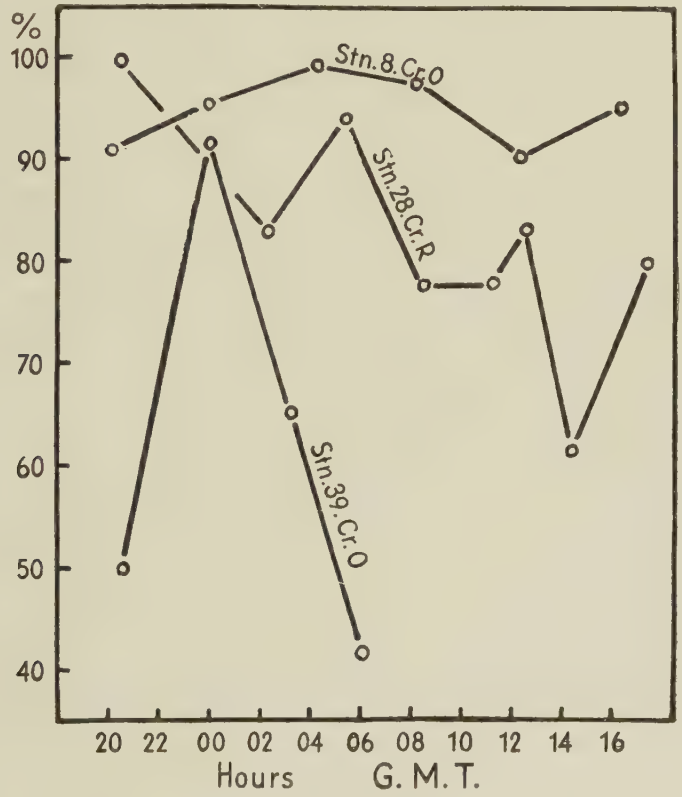


Figure 1. Proportion of *Paracalanus parvus* females containing food at various times of the day and night at Stations 8 and 39, Cruise O, October 1936, and at Station 28, Cruise R, November 1935. The collections of Cruise O were made by tow-nets, those of Cruise R by the Hensen net.

Diurnal differences in the proportion of copepods containing food.

There appears to have been little previous work on diurnal variation in the amount of food observed in the stomachs of zooplankton organisms. For *Calanus,* Marshall [14] has, however, made the interesting observation that in the winter feeding in this species ceases almost entirely during the day, and that bright moonlight has a

deterrent effect. In controlled experiments with *Nitzschia closterium* as food, Fuller [5] has also found some evidence of a diurnal feeding rhythm for *Calanus*, feeding being more pronounced at night. There are also indications from earlier work of my own that there may be a diurnal variation in the food contained by *Sagitta setosa* [20].

The data now presented in Table 1 refer to three positions in that part of the South-Western North Sea which was occupied by patches of the large diatoms *Rhizosolenia styliformis* and *Biddulphia sinensis* in the autumns of 1935 and 1936. The hauls were made at several times of the day and night on each position and the silk used on all occasions had 60 meshes to the linear inch. On Station 28, Cruise R, the hauls were vertical ones made with a Hensen net, but at the two other stations the figures are taken from 5-minute horizontal tows with international nets.

The commonest stage of the commonest copepod in all hauls was the female of *Paracalanus parvus*, and the density of its occurrence which was available for the 1936 stations made it possible to relate it to the number of diatoms in these hauls. The frequency of the big diatoms as caught by the nets was available from all hauls, and it is clear on inspecting the values in Table 1 and those plotted in Figure 1 that the greatest proportion of *Paracalanus* was feeding on Station 8, Cruise O, where the diatoms were most abundant. It is also apparent that on all occasions the highest proportion with food was met with during the hours of darkness.

In the table below I have produced some further evidence on the fractions feeding for *Calanus finmarchicus* and *Sagitta setosa* from Cruise M, October 1934, and for *Sagitta setosa* from the stations of the Flamborough line of 1934. The material for this table has already been published [20] but the figures for the various stations have been sorted and summed in 4-hour periods.

In October both species had a higher proportion feeding by night than by day and the highest proportion for both species occurred in the early part of the night. *Sagitta setosa*, however, examined for the

Table 2.

Time Period	Cruise M. Oct. 1934				Flamborough Line 1934	
	Calanus		*Sagitta setosa*		*Sagitta setosa*	
	Fraction	%	Fraction	%	Fraction	%
1800—2159	42/55	76·4	48/177	27·1	747/4939	15·1
2200—0159	34/46	73·9	73/307	23·8	927/6160	15·0
0200—0559	3/19	15·8	8/37	21·6	1569/6957	22·6
0600—0959	10/53	18·9	52/304	17·1	1646/8183	20·1
1000—1359	48/76	63·2	40/207	19·3	804/5527	14·5
1400—1759	57/100	57·0	73/289	25·3	1455/7393	19·7

year 1934 on the Flamborough line of stations, does not show any notable difference in this respect when night and day are compared. In this connexion it is interesting to recall that the proportion of *Sagitta setosa* feeding at a station outside a phytoplankton patch on Cruise M, 1934 (Wimpenny [20]) showed less variation than that within the patch. It seems likely, therefore, that while the proportion of animals containing food varies directly in relation to the amount of phytoplankton present per zooplankton organism, diurnal range in this fraction may, in some cases, be directly related to the relative density of the phytoplankton. In such circumstances, we might expect to see a big diurnal variation in feeding on short cruises taken at periods of phytoplankton abundance, but in the mixed conditions of a year such a variation would not appear.

A final example of this series concerns the proportions feeding for the three species *Calanus finmarchicus*, *Sagitta setosa* and *Sagitta elegans* taken at two different times of the day in June 1935 off the North-Eastern English coast (Station 23 and 23a, Cruise G 1935, Lat. 54°20′N. 0°37′E.) all tow-nettings being added.

Here again all species show values superior at or near midnight to those of the following morning.

Table 3.

Time	*Calanus*	*S. setosa*		*S. elegans*		Diatoms per litre at		
	%	Fraction	%	Fraction	%	0m.	20m.	40m.
0500	41	$\frac{23}{63}$	37	$\frac{5}{8}$	62	150	2,250	4,225
2350	66	$\frac{17}{35}$	49	$\frac{39}{57}$	68	50	7,850	12,400

An experiment on the proportion of certain copepods containing food related to different supplies.

Lucas [13] in his interesting *in vitro* experiments on the feeding of *Eurytemora hirundoides* and *Neomysis vulgaris* on known cultures of *Nitzschia closterium* came to the following conclusions:—

(1) Given similar food-strengths the rates of feeding may be found to vary inversely with the number of feeders.
(2) Given various food-strengths the rates of feeding may be found to vary directly with the amount of food available.

These two conclusions accord with my deduction that the proportion of zooplankton animals feeding varies directly in relation to the amount of phytoplankton per zooplankton organism. The situation could be put even more shortly by the statement that feeding varies directly as the ratio zooplankton: phytoplankton.

In Lucas's experiments the zooplankton: phytoplankton ratio was higher than in nature. In the experiment I am about to describe this ratio was lower than would be found in the sea. The aim of my experiment was to find out at what rate the proportions of the various

copepods feeding would fall under conditions of over-crowding and relatively diminished food-supply. By this means it was hoped to find how rapid and delicate an index of assimilation conditions at any time and place would be afforded by the observed fraction of copepods containing food. The work was carried out on the course of a plankton cruise (J) in June 1938, when an extra haul of the Hensen net was made at Station 8, where a population consisting mainly of zooplankton had been revealed. From this collection samples of zooplankton of different strengths were introduced into three jars containing roughly

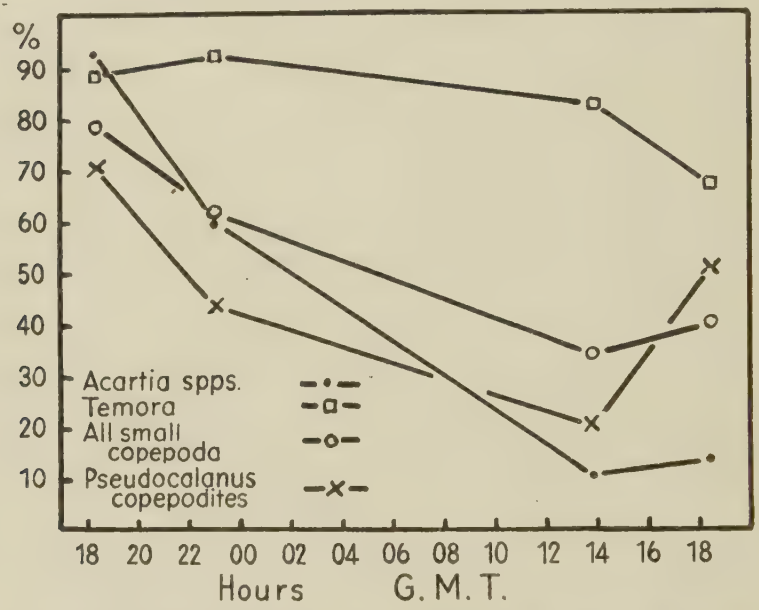


Figure 2. The proportion of *Acartia* spp., *Temora longicornis*, *Pseudocalanus elongatus* copepodites, and "all small copepoda" containing food for Station 8, Cruise J, and samples derived therefrom.

1600 c.c. of surface water from the station. No attempt was made to assess the nanno- and phyto-plankton at the start of the experiment, as the introduction of copepods during the seeding process was thought likely to bring in an indeterminable amount of entangled phyto-plankton. The three jars were allowed to stand 3 hours 45 minutes, 17 hours 40 minutes, and 22 hours 7 minutes respectively, after which their contents were preserved in formalin. All the zooplankton organisms appeared active and healthy in the first two jars, but in the one that had remained longest one or two of the copepods appeared to have become morbid. The jars were kept in an open box in a deck-house of which the door was open. They were, therefore, shielded from direct sunlight. On returning to the laboratory an estimate was made of the number of copepods, the principal species and the proportion feeding for the three jars, and a parallel Hensen haul from

Table 4.

Proportion of copepods containing food, and relative densities of phytoplankton at Station 8, Cruise J, 1938, and samples derived therefrom. Position:— Lat. 55°40′N., Long. 1°29′W.

Date and Time	At Stn. 8 1915-29/VI	In jar A 2300-29/VI	In jar B 1355-30/VI	In jar C 1822-30/VI
All small copepoda per m^3.	2,400	2,470,000	1,312,500	365,000
Diatoms per copepod	—	2.2	0.9	18.4
% All small copepoda with food	79 38/48	62 157/252	34 46/135	40 60/150
Pseudocalanus copepodites per m^3.	700	450,625	421,875	95,625
% *Pseudocalanus* copepodites with food	71 10/14	44 24/55	20 10/50	51 21/41
Temora longicornis per m^3.	450	450,000	234,375	59,375
% *Temora longicornis* with food	89 8/9	93 50/54	83 25/30	67 26/39
Acartia spps. per m^3.	700	1,033,125	187,500	102,500
% *Acartia* spps. with food	93 13/14	60 59/99	10 2/21	13 5/38
Diatoms per m^3. (1,000s)	—	5,200	1,200	6,700
Peridinians per m^3. (1,000s)	—	4,500	4,700	3,200

the original station. In addition the nanno- and phyto-plankton content of the three jars was determined by the sedimentation method using an Utermöhl reversed microscope. These results are shown in Table 4 and in Figure 2.

Though the nannoplankton of the different water layers at the original station was not assessed, nevertheless, on account of the enormous over-crowding in the jars, the nutritive conditions for zooplankton are likely to have been something not less than a hundredfold better. Bearing this in mind, it is notable that there is a considerable falling off in the percentage containing food for the copepods as a whole compared with those taken from their natural habitat. This is the case in all jars and for all species except the *Temora longicornis* over-crowded for 3¾ hours. In this case the copepod does not appear to have shown any effect. Over-crowded for 17 and 22 hours, all species show a considerable drop in the proportion feeding and suggest that the proportion of copepods containing food may be used as a general indication of the balance between copepods and phytoplankton at, and shortly prior to, the time of capture.

The number of diatoms available for each copepod was least (0·9)

in the sample that had been kept 17 hours and which was intermediate in the concentration of its copepod population. For copepods as a whole and for all categories except *Temora longicornis*, where the proportion fell slowly with time, the proportion feeding was least in this jar. Here, in addition to the total of phytoplankton being less than the other two, the diatoms were only a quarter the number of the peridinians, whereas in the other two jars they were in excess. Without knowing something of the effect of time on samples of the same population, densities, and relations, it is not possible to say whether the relative shortage of diatoms was responsible for the minimum proportions shown in the 17-hour sample. It is, however, suggestive and interesting to recall that Dakin [2], Esterly [3], and Marshall [14] have all agreed on the pre-eminence of diatoms as a copepod food and Allen and Nelson [1], Harvey [10], and Fuller [5] record their keeping alive of copepods on diatoms alone. In these circumstances the possibility that diatoms are of essential importance deserves early investigation.

A final general observation common to all the copepods in these over-crowded samples was the disappearance from their body cavities of the rose-coloured oil which was abundant in the copepods from the original station. It seems clear that bad nutrient conditions had resulted in a very rapid and complete mobilization of their food reserves.

Among the separate categories the much higher proportion of *Temora* containing food and the relatively small but steady fall of this proportion in the experimental jars, is worthy of note. When *Temora* contains food it has been noticed in this investigation, and in other work upon which I have been engaged, that the amounts contained are considerable.

The species has been described by Marshall *(loc. cit. supra)* as voracious, eating crustacea as well as diatoms. As in the circumstances of the experiment there was considerable over-crowding, the slow drop in the proportion of *Temora* containing food may well be explained by cannibalism. The two species *Acartia clausi* and *A. longiremis*, to which my category "*Acartia* spps." refers in Table 4, usually contain only a small pellet of food, when food is discernible at all. As will be seen on consulting Table 4 and Figure 2 the effect of reducing the available share of phytoplankton diminished the proportion of *Acartia* spp. containing food from 93 to 10 and 13 % in 17 and 23 hours respectively. These results suggest that digestion in these *Acartia* species can be virtually complete in 24 hours and perhaps considerably less.

Diurnal variation in breeding activity.

In many organisms reproduction is connected with an increase of adult mortality, and as, in any case, its immediate effect is an addition to the number of individual organisms, its importance, when considering the relative numbers of animal and plant communities, makes

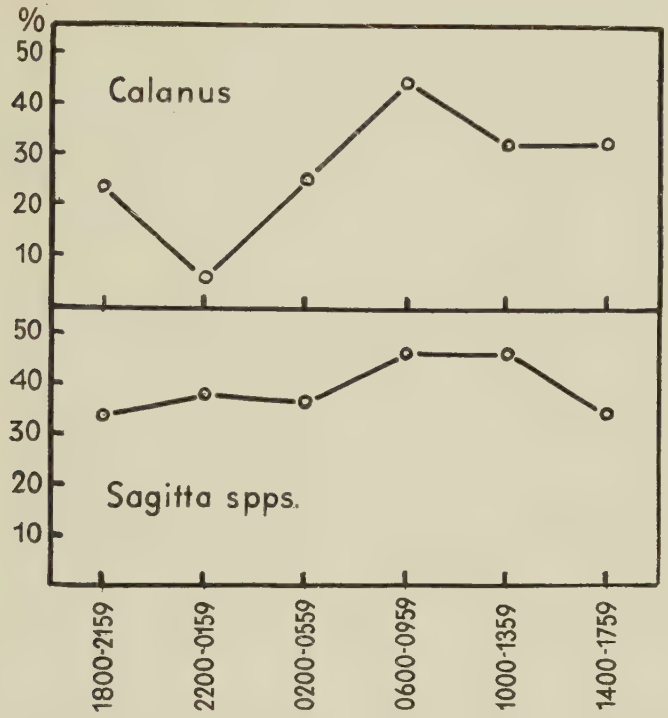


Figure 3. The percentage of stations on which the ova of *Calanus finmarchicus* and *Sagitta* spps. occurred when a number of occurrences are sorted into 4-hour periods.

it claim examination. For the annual cycle of life in fish, reproduction is often the successor of a period of vigorous feeding. This has been well shown by Hardy [8] and Savage [17] in their work on the food of the herring. A cyclicity of varying degrees has also been widely observed in the reproduction of living things. I am not aware, however, of any work which has been done on the daily variation in the reproduction of marine organisms.

For these reasons I present below an analysis of the ova of *Sagitta setosa* found in the tow-nets taken at different depths and times on Station 8, Cruise O, 1936, the dates and positions of which have already been given.

Table 5.

Time		2005	2400	0420	0827	1220	1620
Depth	0 m.	—	—	300	300	600	450
	15 m.	150	—	150	—	600	—
	30 m.	150	—	300	450	450	450
Total		300	—	750	750	1,650	900

Table 6.

Calanus ova per m^3.

Massed Data from Flamborough Line of Stations 1934 and Cruises E and M, June and October, 1934. *All samples taken with the Hensen Net.*

Time Interval G. M. T.	Separate Densities of Occurrence when found	Mean of Densities	Stations of Occurrence for Ova / Stations of Occurrence for Species as a whole	%
1800—2159	95—48—18—6—5	35·4	5 : 21	23·8
2200—0159	125	125·0	1 : 18	5·6
0200—0559	20—105—36	53·7	3 : 12	25·0
0600—0959	97—98—21—171—19—29—5—8	56·0	8 : 18	44·4
1000—1359	102—11—25—5—36—62—4—21	33·2	8 : 25	32·0
1400—1759	5—48—9—8—16—3—22—13—9	14·8	9 : 28	32·1

Sagitta spps. ova per m^3.

Massed Data from Flamborough Line, Cruises E and M, 1934 (already published) and Cruise G, May to June, and J, August 1936 (unpublished) — *Hensen Net Samples.*

Time Interval G. M. T.	Separate Densities of Occurrence when found	Mean of Densities	Stations of Occurrence for Ova / Stations of Occurrence for Species as a whole	%
1800—2159	3—8—9—9—12—17—17—19—32—45—48—59	23·2	12 : 36	33·3
2200—0159	6—8—8—12—13—13—13—15—20—22—31—32—55—158	29·0	14 : 37	37·8
0200—0559	18—20—22—36—57—80—85—137—246	77·9	9 : 25	36·0
0600—0959	5—9—10—11—14—16 18—20—29—31—42—68—86—90—95—102	40·4	16 : 35	45·7
1000—1359	5—7—8—8—10—13—14—15—16—22—33—34—50—51—60—78—82—90—97—233	46·3	20 : 44	45·5
1400—1759	1—8—9—10—12—14—15—16—16—16—17—22—25—29—40—41—41—136	26·0	18 : 53	34·0

Total Ova in 1,000s for all Species.

Vertical Hauls with Fine International Net, Cruise O, 2nd—10th October 1935.

Time Interval G. M. T.	Ova for all Stations of each Period		Mean		Stations at which Ova occurred / All stations for time interval	%
1800—2159	40·5	173·25	10·125	13·3	4 : 4	100
2200—0159	5·25		2·625		2 : 2	100
0200—0559	127·5		18·21		6 : 7	85·7
0600—0959	78·75	426·75	15·75	26·7	4 : 5	80·0
1000—1359	75·75		15·15		5 : 5	100
1400—1759	272·25		45·38		4 : 6	66·7

At midday it will be seen that there was a maximum and at midnight a minimum. The result, though striking, is a single case which might well be fortuitous, and it seemed desirable to analyse other material. This I have done for three sets of data referring to the distribution of ova for *Calanus finmarchicus*, *Sagitta* spps. (mainly *S. setosa*) and ova in general. The first two sets refer to mesoplankton caught by the Hensen net and the third is microplankton material taken with a fine silk (200 meshes to the inch) International net used vertically.

These observations, as set down in Table 6 above and plotted in Figure 3, have been divided into 4-hour periods. Their source is the South-Western North Sea, and in the case of *Calanus* and the *Sagitta* spps. they are fairly well distributed in season and time. There were 112 stations available for a consideration of the *Calanus* ova distribution, and 239 for that of *Sagitta* spps.; for the microplankton, however, the observations are limited to one cruise of 29 stations. It is evident from a consideration of the *Calanus* and *Sagitta* data that ova were more widely distributed over the area occupied by the species during the hours of daylight. The mean density of the ova when they were found was greatest in the four hours following 6 a.m. for *Calanus*, but for the *Sagitta* spps. this maximum fell in the preceding period. Taken together these circumstances suggest the laying of eggs about the break of day and their subsequent dispersion over a wider area. The zooplankton ova from the microplankton collections do not, I think, provide enough cases to give an idea of the relative spread of distribution by night and by day, but it is clear that actual numbers found were much greater by day than by night.

From these examples I am led to suspect that there is either a tendency for zooplankton organisms in our latitudes to extrude more eggs by day or that the conditions of survival are so much better by day, that there is a discernible diurnal variation in their numbers on this account. In any case, there is reason to suspect a relation between the breeding and early development of zooplankton and the hours of daylight. A relation between the breeding and early development of zooplankton and the areas dense in diatoms has already been pointed out (Wimpenny [20]). Here it was suggested that some effect of the plant's metabolism, possibly oxygen, which ova and embryos demand at a great rate, was the favourable agent. The speculation that the spatial and diurnal relations of breeding zooplankton and diatoms are both affected by the synthetic activity of diatoms is, therefore, not an illogical one.

Diurnal variation in the numbers of diatoms.

If there is more feeding by copepods at night, there should be a corresponding diurnal mortality among the diatoms which form their food. On the other hand, it has been stated elsewhere (Fritsch [4]) and confirmed for *Rhizosolenia styliformis* and *Biddulphia sinensis* by Savage and Wimpenny [18] that diatoms tend to divide by

Table 7.

Cruise O, Station 8, 1936.
Tow-nets at 0, 15, and 30 metres and combined.

Time and Date		2005 7.X	2400 7—8.X	0420 8.X	0827 8.X	1220 8.X	1620 8.X
Biddulphia sinensis							
(1,000s) at	0 m.	609	186	1,797	822	426	957
	15 m.	714	552[1])	1,194	2,775	1,080	1,371
	30 m.	807	78	1,830	2,325	1,089	2,940
	all depths	2,130	816	4,821	5,922	2,595	5,268
% dividing at	0 m.	29·1	35·5	22·2	20·8	14·8	16·0
	15 m.	16·8	28·3[1])	18·8	22·4	17·5	22·5
	30 m.	23·4	21·2	15·6	25·2	12·9	19·4
	all depths (Weighted mean)	22·8	28·5	20·3	22·4	15·1	19·8

[1]) 16 metres.

Cruise M, Station 37, 1937.
Lat. 54°07′N., Long. 2°21′E. to Lat. 54°05′N., Long. 2°22′E.
Tow-nets at 0, 18, and 36 metres combined.

Time and Date	1423 17.X	1833 17.X	2222 17.X	0229 18.X	0643 18.X	1019 18.X
Biddulphia sinensis						
(1,000s)	12,117	16,380	18,900	14,625	26,625	45,450
% dividing	34·9	32·9	36·5	42·6	31·3	26·2

night. It should be noted, however, that the diatoms which were noted by Savage and Wimpenny as "dividing", and which are meant by that word in this paper, were all cells in which the outer frustule was still entire, and it is unlikely that such cells would become two independent units for some hours after this stage. For this reason a rhythmic daily increase might well be sought in the diatom population.

With these considerations in view diurnal observations are being made as opportunity permits on the routine cruises of the Ministry of Agriculture & Fisheries' Research Vessel "George Bligh". In view of the fact that the wind tends to drive a drifting ship out of the original water mass which she started to sample at the time the observations began, a considerable number of 24-hour stations, and some *in vitro* experiments will be necessary before the existence of a daily diatom increase can be shown. In the meantime the results of two 24-hour stations now available offer results not inconsistent with the thesis. An abstract from these series, which were both taken in the autumn in an area with a considerable *Biddulphia* population, is shown in Table 7. In both cases the diatom is revealed as having its greatest numerical density by day and a greater proportion dividing by night. If a diurnal cycle of this sort is found to be general among diatoms, it would offer another explanation of Hardy's observation [6] that there was a greater proportion of the diatom *Coscinodiscus bouvet* in the upper layers of the Antarctic Ocean by day than by night. For

instead of having to postulate a daily upward vertical movement of diatom cells, the two factors (1) relatively greater feeding of copepods and (2) final separation of each diatom into two by day after having undergone preliminary stages of division by night, acting upon a stationary population might well produce the result to which H a r d y has drawn attention.

Discussion.

The ecological relations which have been dealt with in this note may be more properly characterized as belonging to the physiological foundations of marine ecology. As the systematic ecology of the plankton is itself still in an elementary stage, our knowledge of the underlying physiology is yet more limited. With the very small amount of data available we must, therefore, be content to advance tentative hypotheses at present nearer conjecture than conclusion. Nevertheless, it is hoped that the observations now offered will attract attention to the subject and stimulate its investigation more widely in time and space.

With these reservations I suggest that the preceding examples give us cause to look for the following trends of behaviour in the zoo- and phyto-plankton communities:—

Zooplankton. In the presence of abundant phytoplankton, a high proportion feeding and little diurnal variation. (See *Paracalanus parvus* females at Station 8, Cruise O, Table 1). With a lower zooplankton: phytoplankton ratio, a lower proportion feeding and a greater diurnal variation. (See *Paracalanus parvus* females at Station 39, Cruise O, Table 1). When the ratio is least, the least proportion of feeding zooplankton and again little diurnal variation (*Sagitta setosa* in and outside the diatom patch of Cruise M, 1934 [20]). A general direct relation between the proportion of zooplankton feeding and the number of diatoms present per zooplankton organism. (See Table 1 and [20]). Greater assimilation by zooplankton at night (see Tables 1, 2 and 3) and where phytoplankton is abundant, greater reproduction by day. (See Tables 5 and 6).

Phytoplankton. Assimilation by day and a preponderance of vegetative reproduction by night consisting of the internal division of cells which may be expected to free themselves during the day.

These trends may be tabulated as follows:—

	Night	Day
Zooplankton	Assimilation (Grazing)	Reproduction (Deposition of ova)
Phytoplankton	Reproduction (Vegetative division)	Assimilation (Photosynthesis)

The reciprocity of this scheme recalls the general reciprocity of animal respiration and plant assimilation.

If further observation gives general significance to the trends

which I have just put forward, it is interesting to consider the daily increase and nightly decrease which could in certain circumstances affect the diatom population. The extra grazing of animals by night would tend to cause a decrease and the greater separation of diatom cells by day an increase in the diatom population. That changes in the diatom population may be considerable over quite short periods has been shown repeatedly. Even a large diatom may divide once in four days giving an optimum daily rate of 25 % for a species as big as *Rhizosolenia styliformis*. For the particular diatoms treated here we have, however, no experimental evidence to offer on their differential grazing down by night. The conception of importance is that mortality and growth in diatoms may be at their height at different times and that this may explain apparent migrations into the photic zone.

Summary.

1. It is submitted as a tentative hypothesis that at certain stages in the mutual relations of the zooplankton and phytoplankton communities, there is greater assimilation by night and reproduction by day in the zooplankton. This is the opposite of the greater vegetative reproduction as shown by the more numerous dividing stages in the phytoplankton at night and the assimilation by day.
2. The proportion of food-containing copepods appears to be a rough index of the zooplankton: phytoplankton ratio, considering only the populations sampled by coarse silk nets.

Bibliography.

1. Allen, E. J. & Nelson, E. W. On the Artificial Culture of Marine Plankton Organisms. Journ. Mar. Biol. Assoc. U.K., N.S. VIII, 421, Plymouth, 1910.
2. Dakin, W. J. Notes on the Alimentary Canal and Food of the Copepoda. Internat. Rev. d. ges. Hydrobiol. usw., I, 772, Leipzig, 1908.
3. Esterly, C. O. The Feeding Habits and Food of Pelagic Copepods and the Question of Nutrition by Organic Substances in Solution in the Water. Univ. of Calif. Publ. in Zoology, XVI, 171, Berkeley, 1916.
4. Fritsch, F. E. Structure and Reproduction of the Algae. Vol. I. Cambridge, 1935.
5. Fuller, J. L. Feeding Rate of *Calanus finmarchicus* in Relation to Environmental Conditions. Biol. Bull. Woods Hole, Mass., LXXII, 233, U.S.A., 1937.
6. Hardy, A. C. in Hardy, A. C. & Gunther, E. R. The Plankton of the South Georgia Whaling Grounds and Adjacent Waters 1926—27. Discovery Rep., XI, I, Cambridge, 1935.
7. Hardy, A. C. Plankton Ecology and the Hypothesis of Animal Exclusion. Proc. Linn. Soc. London, 148th Session, Part 2, 64, London, 1936.
8. Hardy, A. C. The Herring in Relation to its Animate Environment. Part I. The Food and Feeding Habits of the Herring with Special Reference to the East Coast of England. Min. Agric. & Fish., Fish. Invest. Ser. II, VII, No. 3, London, 1924.
9. Harvey, H. W. Annual Variation of Plankton Vegetation, 1933. Journ. Mar. Biol. Assoc. U.K., N.S. XIX, 775, Plymouth, 1934.
10. Harvey, H. W. Note on Selective Feeding by *Calanus*. Journ. Mar. Biol. Assoc. U.K., N.S. XXII, 97, Cambridge, 1937.

11. Jenkin, P. M. Oxygen Production by the Diatom *Coscinodiscus excentricus* Ehr. in relation to Submarine Illumination in the English Channel. Journ. Mar. Biol. Assoc. U.K., N.S. XXII, 301, Cambridge, 1937.
12. Lucas, C. E. On the Diurnal Variation of Size Groups of Trawl-Caught Herring. Journ. du Conseil, XI, 53, Copenhagen, 1936.
13. Lucas, C. E. On Certain Inter-Relations between Phytoplankton and Zooplankton under Experimental Conditions. Journ. du Conseil, XI, 343, Copenhagen, 1936.
14. Marshall, S. M. The Food of *Calanus finmarchicus* during 1923. Journ. Mar. Biol. Assoc. U.K., N.S. XIII, 473, Plymouth, 1925
15. Marshall, S. M., Nicholls, A. G. & Orr, A. P. On the Biology of *Calanus finmarchicus*. Part VI. Oxygen Consumption in Relation to Environmental Conditions. Journ. Mar. Biol. Assoc. U.K., N.S. XX, 1, Plymouth, 1935.
16. Russell, F. S. The Vertical Distribution of Plankton in the Sea. Biol. Rev. Cambridge Phil. Soc., II, 213, Cambridge, 1927.
17. Savage, R. E. The Relation between the Feeding of the Herring off the East Coast of England and the Plankton of the Surrounding Waters. Min. Agric. & Fish., Fish. Invest., Ser. II, XII, No. 3, London, 1931.
18. Savage, R. E. & Wimpenny, R. S. Phytoplankton and the Herring. Part II. 1933 and 1934. Min. Agric. & Fish., Fish. Invest., Ser. II, XV, No. 1, London, 1936.
19. Steemann Nielsen, E. On the Relation between the Quantities of Phytoplankton and Zooplankton in the Sea. Journ. du Conseil, XII, 147, Copenhagen, 1937.
20. Wimpenny, R. S. The Distribution, Breeding and Feeding of some Important Plankton Organisms of the South-West North Sea in 1934. Part I. *Calanus finmarchicus* (Gunn), *Sagitta setosa* (J. Muller), and *Sagitta elegans* (Verrill). Min. Agric. & Fish., Fish. Invest., Ser. II, XV, No. 3, London, 1936.

A Routine Method for the Estimation of Fat in Plankton and its Application to Herring Tissues.

By

R. S. Wimpenny.

THE special importance of fat as the most extensive and variable food-reserve in plankton catches of different constitution was long ago established by Brandt [1]. The specific fat-content of various species of marine organisms making up the plankton, and also of fish and littoral organisms, has since been the subject of special investigations by a number of workers. Among these may be cited Bruce [2] for the herring, Bull [3] for the sprat, Delff [4] for littoral organisms, and Orr [7 & 8] for *Calanus finmarchicus* and *Euchaeta norvegica*. The result of this work has been to show the important variations between species, between different stages in the development of the same species, and in the same species at different seasons. In the case of the herring, Bruce has also demonstrated the reciprocal relation of fat- and water-content.

During 1926 estimates of the variation in fat-content for plankton catches made over the area of the herring grounds off the east coast of England were carried out by the present writer [11] on several voyages. This preliminary investigation suggested a spatial difference in the fat-content of the plankton, that of the northern part of the area giving the highest values. The results were expressed as milligrammes of ether-soluble matter per 1,000 organisms, a circumstance dictated by the use of an adaptation of Meig's method for the estimate of fat in milk. Two samples in this work were, however, assessed by a method of Soxhlet extraction, and expressed as a percentage of the dry weight for the sample.

It is this method which is now to be described, and which has been in use for voyages covering the English east coast herring grounds in June and October each year since 1932. In addition it has been applied to the six Hensen-net catches which have been made each month since that year, along a line joining Flamborough Head and the SW. Patch of the Dogger Bank.

Apart from information on the fat-content of specific organisms which occasionally make up the whole catch, valuable data on the spatial, seasonal and yearly variation of the important food-reserve have been obtained by the use of this method. These results will be published elsewhere; it merely remains in this connexion to stress the importance of fat-content in the net plankton as an index of the success of organic production at any place or time. The significance of this index for the contemporary or subsequent success and condition of the food-fish populations does not need emphasizing, and it is suggested that the method described might usefully be employed as a regular routine over a wider geographical range by workers in other areas.

Figure 1. Glass extraction tubes stopped with glass-wool. That on the left is empty, the middle one contains a sample which is almost pure phytoplankton, and that on the right contains pure powdered zooplankton.

The Method.

The plankton catch that has been used is that caught by a Hensen-net using silk containing 60 meshes to the linear inch. Immediately after the haul, the catch is scraped from the silk at the bottom of the net bucket and transferred to a filter paper folded funnel-shape and placed in the top of a 1-lb. jar containing the station label. The silk is then washed in a small basin and the washings are poured into the filter paper. When the superfluous water has drained off, and has been thrown out of the jar, the sample is placed to dry in a rack constructed over the ship's engine, where a temperature of 60°C. is obtained. On the sample reaching the appearance and texture of a lightly cooked biscuit, it is removed and sealed in its jar. As soon as the ship returns to port, the sample is crumbled to a course powder and poured into a numbered glass tube having a hole in the bottom

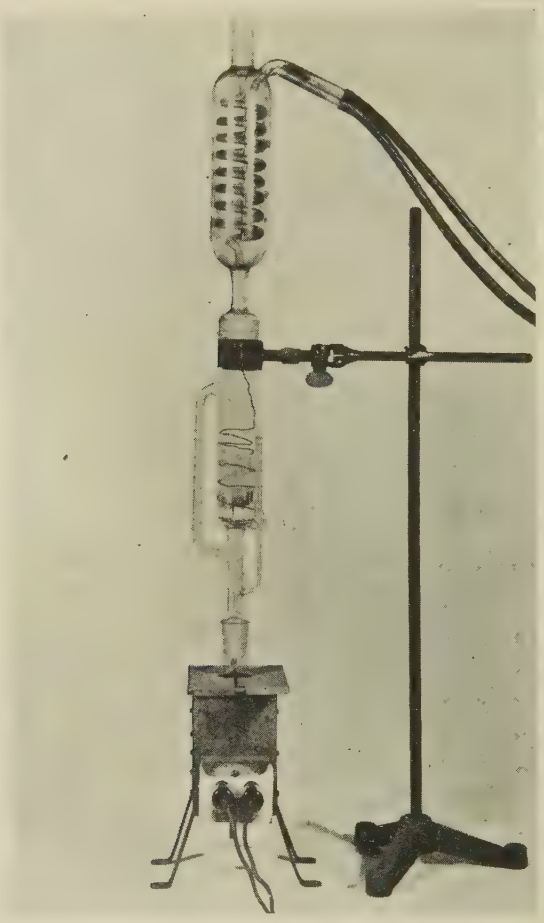


Figure 2. A Soxhlet apparatus extracting ten samples.

stopped with glass-wool (Fig. 1). Each of a series of such numbered glass tubes is weighed and prepared beforehand, and after the tubes have been dried in an oven at 80°C. for forty-eight hours they are again weighed together with their contained samples. The tubes are then extracted with ether in a Soxhlet apparatus, six to ten at a time, surrounded by a copper wire spiral to facilitate their withdrawal (Fig. 2). Though for technical convenience in taking the photograph only one Soxhlet apparatus is shown, a battery of six is generally used, allowing up to sixty samples to be extracted together. The extraction proceeds for nine hours, after which the samples are withdrawn and placed to dry for another forty-eight hours in the oven at 80°C. They are then weighed again. The third weight subtracted from the second and then expressed as a percentage of the first

subtracted from the second gives the percentage of ether-soluble matter in the sample dried to 80°C.

Advantages in the use of small glass tubes as extraction thimbles are, first, that on account of the extremely small size of the dried samples (often only 50 mgm., particularly in the winter) it is impossible to work with the ordinary extraction thimbles, which would produce a considerable relative error in weight, owing to their absorption of atmospheric moisture. This, glass does not do. Secondly, the narrow glass tubes allow of a number being packed in each Soxhlet apparatus and by using the method of weighing by difference, one has the convenience of being able to carry out a large number of estimates together.

There are certain difficulties and objections to the method, some of which can be avoided. During extraction particles may float over the top of the extraction tube, and during drying the powder may "explode" over the top. Both these effects can be avoided by beginning the extraction and the drying very gradually.

The freshly caught plankton was drained and dried on filter paper, and as it was found that washing with distilled water caused disruption of the organisms no attempt was made to wash away the small quantity of adherent sea water which must be evaporated to dryness with each sample. A small amount of chloride will therefore tend to make the "fat values" a slightly less percentage than they would have been without it. Moreover, drying to 80°C. does not remove all the water and, again, the estimated percentage of the dry weight will tend to be on the low side. The original decision to dry at 80°C. was, however, arrived at in order to safeguard against loss of oil due to volatility and it has been maintained since for the sake of comparability. Finally, the direct extraction by ether removes substances other than fat.

While the method can therefore make no claim to great precision, it has given results consistent with regarding it as a reliable index, and where comparisons are possible it has been found to give results in harmony with those obtained by other means.

Results.

The Annual Cycle in the Plankton and in Herring Muscle.

The means of the percentages obtained for six Hensen-net catches made each month in 1935 on the six Flamborough Line stations are shown in Figure 3, where the values are joined by a dashed line. In the Table 1 there are also given the individual values for each station.

While the different years vary in the relative importance of the seasons in the annual cycle and also in the general level of values for the whole year, 1935 shows two features which have appeared in all the years hitherto investigated. This is the low level in February and the peak in summer. There is also a minor rise in the autumn. Biologically these two maxima may be related to the spring and autumn outbursts of diatoms which are predecessors of fat-storage by

the zooplankton. In Figure 3 there have also been plotted for comparative purposes the mean percentages of fat obtained from the muscles of ten herrings collected at fortnightly intervals for a considerable period at North Shields and during the autumn herring fishery of East Anglia. The individual values appear in Table 2.

The percentage of fat in the herring muscle is seen to rise steeply from April to a maximum in July, whence it begins to recede. Comparing the course of the herring fat values with that for the

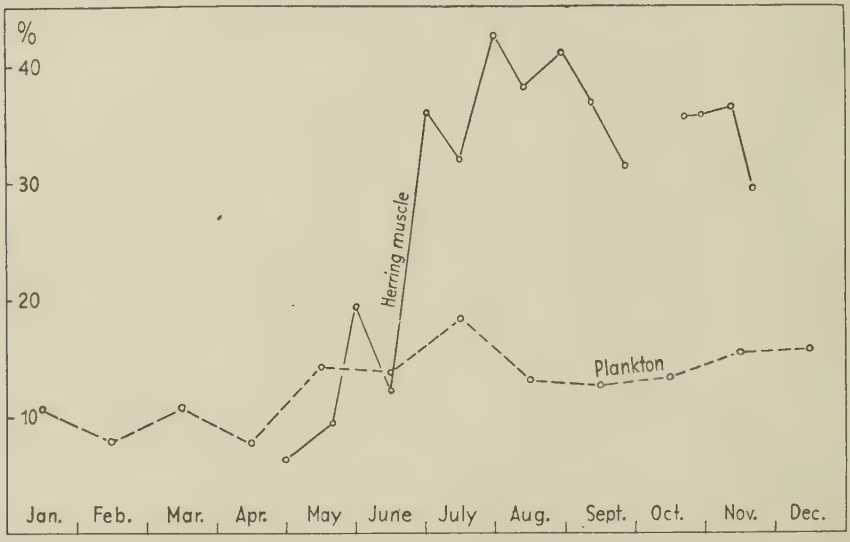


Figure 3. The mean monthly percentages of ether-soluble matter for the six Flamborough Line stations are joined by a dashed line. The mean percentage of ether-soluble matter for the muscles of samples of herring are joined with an entire line. From May to September the herring were from North Shields, in October and November from East Anglia.

plankton of the Flamborough Line, it is clear that the former reaches its peak later than that of the plankton. Work on the food of the herring, particularly that of S a v a g e [9], has shown that it is similar to the plankton caught in the Hensen-net for the period covered by these observations. A dependent and successive correspondence of the two sets of fat values is, therefore, not difficult to understand. The fat-content of the Shields herring muscle during July and August is actually higher than is shown by my figures, as at this time of the year liquid oil runs out of the muscle, making it impossible to dry and extract accurately by this method.

L o v e r n and W o o d [6], who have given fat analyses of herring for different stocks of North Sea herring as a result of using summed samples during the same period as these observations, reach an identical conclusion. They give a minimum for the fat in herring flesh in April, a steep rise through May and June to a maximum in July. Thereafter, there may be a fall at different rates depending on the spawning

Table 1.

Ether-soluble Matter (%) in Plankton from Hensen-Net Hauls at the Different Stations of the Flamborough Line in 1935.

Flamborough Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	5·4	6·8	9·5	4·4	7·2	17·9	4·7	10·3	13·3	6·1	1·6	11·5
2	11·4	10·6	13·5	9·8	21·6	13·7	32·8	13·3	10·1	19·2	18·4	13·2
3	11·0	8·3	11·6	9·2	15·7	6·2	29·3	16·6	13·3	17·0	17·1	26·0
4	9·9	9·6	9·3	—	3·2	6·1	23·6	15·8	12·9	13·5	22·8	19·6
5	13·1	4·4	15·6	—	18·0	17·1	14·4	11·8	9·8	14·3	19·4	12·3
6	13·1	—	5·3	—	20·6	21·8	5·7	11·2	16·2	10·0	13·3	11·8
Mean	10·6	7·9	10·8	7·8	14·4	13·8	18·4	13·2	12·6	13·4	15·4	15·7

season. At Shields, the shape of the seasonal curve resembles that given by Lovern and Wood for "Scottish autumn spawners", although the Shields population is somewhat heterogeneous. According to Hodgson [5] the Shields fishery commences with four-year-old recovering spents continuing from May to July or August with fat virgin fish in their third year and ending with older fish which are preparing to spawn. In these circumstances it seems likely that the seasonal picture of fat-content as presented here and by Lovern and Wood from April to August, is a general one.

Individual Variation and Lunar Periodicity.

On more than one occasion it has been pointed out to me by canners and those who deal with herring in the fresh condition that the taste and condition of individuals from the same catch and which appeared to be fish of similar size and age varied considerably. In these circumstances it was thought that a variation in fat-content would be a likely cause of the quality difference. Accordingly, all the estimates given in this paper were made on individual fish for the purpose of determining whether there were any important differences among fish landed at the same time. The fish were usually taken in samples of ten. Further, in view of the marked lunar periodicity in the behaviour of the East Anglian autumn herring, recently shown by Savage and Hodgson [10], the samples were taken as near the dates of the full and new moons as possible, in order to see if the difference in behaviour had a physiological side.

While, for most of the period investigated, there is an interesting drop in the mean fat value for the muscle of Shields fish at the dates of the full moon, we must defer consideration of this aspect of the matter for these fish until a method is used which gives full account of the high values for July and August. With the East Anglian fish we can deal with more precision. In Tables 2 and 3 there are shown fat values for the muscles of herring taken during the East Anglian fisheries of 1934, 1935, and 1937, and in Figure 4 they are plotted on diagrams which show the times of the new and full moons.

Table 2.

Ether-soluble Matter (%) in Muscle of Individual Herring dried at 80°C.

N. Shields, 1935.

	New Moon 2nd 1.5.35	Full Moon 18th 20.5.35	New Moon 1st 1.6.35	Full Moon 16th 14—15.6.35	New Moon 30th June 2.7.35
	7·2	9·3	15·3	10·6	40·2
	2·6	9·5	12·3	8·3	41·8
	4·7	7·7	28·6	9·2	38·3
	5·7	7·9	16·9	16·2	34·2
	8·8	12·7	19·9	10·9	33·2
	5·4	8·1	23·6	11·9	31·1
	6·4	6·2	32·4	15·4	31·2
	8·9	14·4	21·4	9·5	40·0
	5·5	11·4	14·7	18·8	34·7
	7·3	8·2	9·1	—	36·6
Mean	6·2	9·5	19·4	12·3	36·1

	Full Moon 16th 15.7.35	New Moon 30th 30.7.35	Full Moon 14th 13.8.35	New Moon 29th 29.8.35	Full Moon 12th 12.9.35	New Moon 27th 26—27.9.35
	32·8	30·1	40·7	39·3	29·3	28·9
	33·1	37·4	33·9	62·5	46·2	6·2
	27·4	46·6	39·0	40·8	34·2	36·8
	33·2	47·1	36·2	39·7	28·2	38·0
	40·0	41·1	42·0	37·2	37·1	35·9
	27·1	50·0	36·3	50·1	40·9	42·7
	39·9	47·3	42·4	28·3	47·1	36·5
	29·4	38·1	41·6	33·4	27·9	38·3
	30·2	47·5	31·3	43·1	38·9	35·8
	27·0	39·6	38·8	38·0	39·2	16·2
Mean	32·0	42·5	38·2	41·2	36·9	31·5

E. Anglia, 1935

	New Moon 27th 22.10.35	Full Moon 10th 29.10.35	New Moon 26th 12.11.35	21.11.35
	39·3	35·6	40·8	28·3
	47·8	32·6	37·6	25·6
	38·1	33·1	40·9	32·6
	36·0	29·6	37·7	29·0
	20·6	43·7	35·9	31·2
	29·1	32·5	40·9	24·6
	37·5	35·0	38·7	38·6
	31·2	34·9	38·3	21·0
	33·1	33·1	28·7	34·9
	43·3	39·6	33·9	28·3
	—	—	29·9	—
Mean	35·6	35·0	36·7	29·4

Table 3.

Ether-soluble Matter (%) in Muscles of Individual Herring. E. Anglian Samples.

1934		
	Full Moon 22nd	New Moon 7th
18.10.34	23.10.34	8.11.34
25·6	16·0	10·2
13·0	17·0	12·4
14·7	15·8	13·6
21·9	28·3	13·2
22·0	19·4	10·4
22·4	7·4	10·8
10·5	11·3	14·1
15·3	22·6	11·7
10·6	16·1	15·0
16·1	13·1	9·8

1934	
Full Moon 21st	New Moon 6th
22.11.34	4.12.34
15·4	15·0
9·5	12·2
19·3	18·4
10·2	15·3
16·1	12·3
16·5	8·5
21·9	13·8
13·7	15·3
18·4	16·4
14·7	12·1

1937	
New Moon 3rd	Full Moon 18th
5.11.37	19.11.37
31·8	27·3
37·0	10·3
27·9	28·4
33·1	32·2
36·4	43·5
29·8	16·8
33·1	29·5
25·2	26·8
26·1	33·1
28·7	46·7

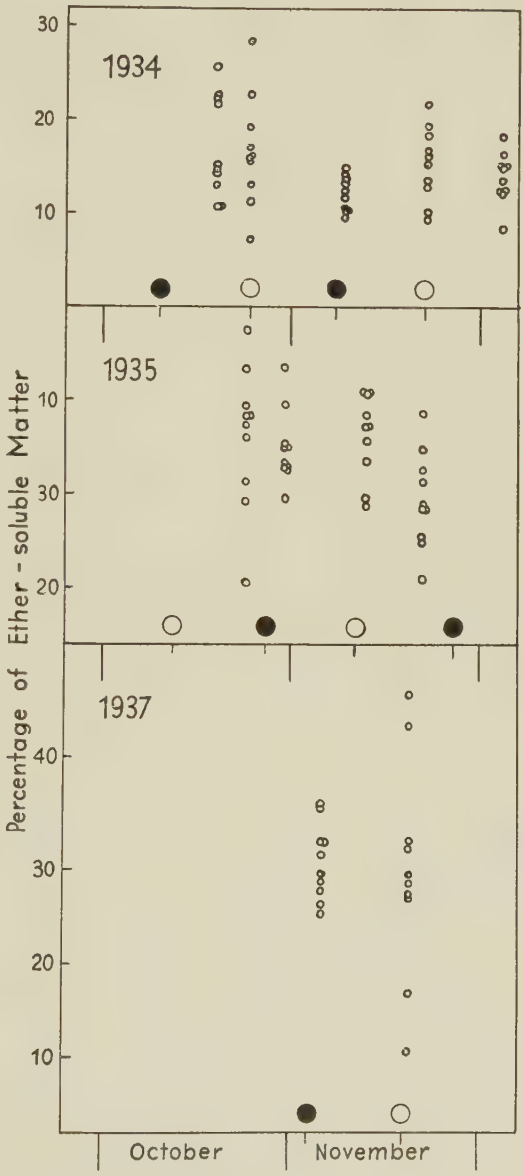


Figure 4. The distribution of the ether-soluble matter percentages for individual East Anglian fish caught in 1934, 1935, and 1937. The times of new and full moon are shown by black and white circles respectively.

It is immediately apparent that the individual values vary considerably and that in both 1934 and 1937 there was a greater spread at the period of the full moon. This greater spread was not evident in 1935, but even in this year it must be pointed out that the only sample having seven values concentrated within a 4 per cent. range was the one nearest the new moon in October. As far as these few results go, therefore, it would appear more likely to get a fish of uniform quality from the East Anglian herring fishery at the time of the new moon, than during the full moon glut. If the course of events suggested by these few observations turns out to be generally true for the East Anglian fishery, the wide range of fat values found in the muscles of herrings caught at the time of the full moon may be due to a greater variety of activity indulged in by the fish during their great and sporadic "swims". This might be expected to cause a greater mobilization and a greater variety of stages in the use of fat as the ultimate source of kinetic energy.

Age, length, and sex were determined for many of the samples just discussed, but the fat-content did not show an obvious connexion with any of these factors over the range presented by the data.

The Translocation of Fat from the Liver to the Gonads.

Figure 5 and Table 4 show the relation between the fat-contents of the liver and the gonads during a part of the East Anglian fishery of 1935.

Male and female values were similar for the liver, and in the diagram they have been treated together. In the case of the gonads, however, the males showed a higher content. Comparing the course

Table 4.

Ether-soluble Matter (%) in Individual E. Anglian Herring dried at 80°C.

	1935					
	Livers			Gonads		
	15.10.35	22.10.35	29.10.35	15.10.35	22.10.35	29.10.35
	42·3	16·9	18·0	8·1	5·6	16·1
	17·4	14·3	21·8	5·4	6·3	5·0
	11·7	21·4	13·1	5·6	6·0	5·6
♀	19·1	22·1	8·4	5·5	8·1	7·2
	26·6	20·1	7·9	4·9	6·6	6·7
	—	26·0	—	5·7	4·6	—
	—	11·6	—	—	8·6	—
Mean	23·4	18·9	13·8	5·9	6·5	8·1
	33·8	9·4	13·7	13·8	14·2	12·2
	37·2	46·6	29·9	15·9	13·0	11·1
♂	28·5	28·8	22·6	13·1	12·8	12·0
	23·3	—	15·4	13·9	—	11·2
	—	—	26·8	—	—	13·5
Mean	30·7	28·3	21·7	14·2	13·3	12·0
Mean of all	26·7	21·7	17·8	9·2	8·6	10·1

of events for the liver and the gonads, we see that for the three samples dealt with, there was a drop in liver values and an increase for those of the gonads taking both sexes together. This fattening of the gonads at the expense of the liver and the sexual difference are in full accord with the observations of Bruce [2] for Irish Sea and Clyde material.

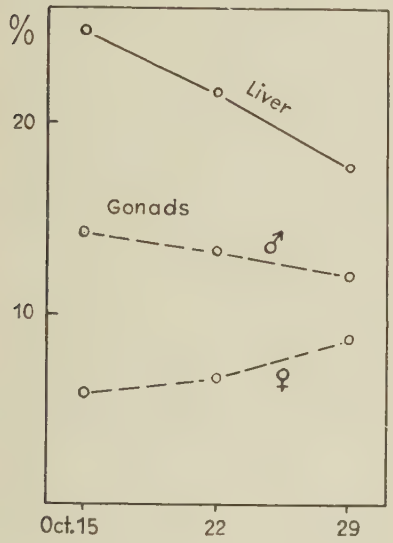


Figure 5. The mean percentage of ether-soluble matter in the liver of both sexes (entire line) and in the gonads of each sex (dashed line) for three samples of the East Anglian herring fishery taken in October 1935.

Zusammenfassung.

1. Eine Methode wird beschrieben zur routinemässigen Gewinnung von Fett aus Plankton Proben.
2. Angewandt auf Plankton und Hering Gewebe zeigen einige Ergebnisse dieser Methode, dass in der Fettentwicklung in den Muskeln von Shields Hering des Jahres 1935 ein von den Jahreszeiten bedingter Kreislauf bestand. Der Höhepunkt dieses Kreislaufes folgte dem des gleichzeitigen Planktons.
3. Die Methode eignet sich nicht für die sehr hohen Werte, die man manchmal in Shields im Juli und August bei den Herings Muskeln antrifft. Es kann aber trotzdem eine beträchtliche Schwankung zwischen einzelnen Individuen nachgewiesen werden, und für die ostanglische Fischerei besteht die Vermutung, dass diese Schwankung bei Vollmond grösser ist als bei Neumond.
4. Die männlichen Gonaden hatten einen weit grösseren Fettgehalt als die weiblichen, und im Verlauf des Reifeprozesses zeigte sich bei dem ostanglischen Herbstfisch von 1935 ein Abnehmen im Fettgehalt der Leber und ein Zunehmen im Fettgehalt der Gonaden. Diese Beobachtungen bestätigen diejenigen von Bruce für den Hering von Manx und Clyde.

Bibliography.

1. Brandt, K. "Beiträge zur Kenntnis der chemischen Zusammensetzung des Planktons." Wiss. Meeresunters., Abt. Kiel, N.F. III, 45, Kiel und Leipzig, 1898.
2. Bruce, J. R. "Changes in the Chemical Composition of the Tissues of the Herring in relation to Age and Maturity." Biochem. Journ., XVIII, 469, London, 1924.
3. Bull, H. Årsberet. vedk. Norges Fiskerier, 1912. Bergen.
4. Delff, C. "Beiträge zur Kenntnis der chemischen Zusammensetzung wirbelloser Meerestiere." Wiss. Meeresunters., Abt. Kiel, N.F. XIV, 51, Kiel und Leipzig, 1912.
5. Hodgson, W. C. "The Natural History of the Herring of the Southern North Sea." Buckland Lectures for 1933. London, 1934.
6. Lovern, J. A. and Wood, H. "Variations in the Chemical Composition of Herring." Journ. Mar. Biol. Assoc. U.K., N.S., XXII, 281, Cambridge, 1937.
7. Orr, A. P. "The Weight and Chemical Composition of *Euchaeta norvegica*, Boeck." Proc. Roy. Soc. Edinburgh, LIV, 51, Edinburgh, 1934.
8. Orr, A. P. "On the Biology of *Calanus finmarchicus*. Part IV. Seasonal Changes in the Weight and Chemical Composition in Loch Fyne." Journ. Mar. Biol. Assoc. U.K., N.S., XIX, Plymouth, 1934.
9. Savage, R. E. "The Relation between the Feeding of the Herring off the East Coast of England and the Plankton of the Surrounding Waters." Min. Agric. and Fish., Fish. Invest., Ser. II, Vol. XII, No. 3, London, 1931.
10. Savage, R. E. and Hodgson, W. C. "Lunar Influence on the East Anglian Herring Fishery." Journ. du Conseil, IX, 223, Copenhagen, 1934.
11. Wimpenny, R. S. "Preliminary Observations on the Fat-Content of the Plankton on the English Herring Grounds in the North Sea." Min. Agric. and Fish., Fish. Invest., Ser. II, Vol. XI, No. 5, London, 1929.

Ein Apparat zur Entnahme von Meerwasserproben aus der Tiefe für bakteriologische Untersuchungen.

Von

Helmut Schach,
Biologische Anstalt, Helgoland.

APPARATE, mittels derer man aus den verschiedensten Tiefen von Brunnen, Flüssen und Seen Wasserproben entnimmt, um sie auf die in ihnen vorkommenden Bakterien zu untersuchen, sind im Handbuch Ohlmüller-Spitta "Untersuchung und Beurteilung des Wassers und des Abwassers" und im Abderhaldenschen Handbuch der biologischen Arbeitsmethoden von A. Splittgerber-Wolfen und E. Nolte beschrieben. Diese Apparate sind im Prinzip ihrer Arbeitsweise die gleichen, wie sie bei der Meeresbakteriologie Verwendung finden. Sie eignen sich jedoch wegen der wesentlich anderen Anforderungen, die an sie gestellt werden, nicht *auch* für das Arbeiten an Bord von Schiffen auf See. W. Benecke hat die Bakteriologie des Meeres im Abderhaldenschen Werk bearbeitet und die Methode der Probenentnahmen verschiedener Meeresbakteriologen wiedergegeben. In diesem Werk ist auch eine Zusammenstellung der Arbeiten über Apparate zur Entnahme von Wasser- und Grundproben zu finden.

Die Forderung, bei meeresbakteriologischen Untersuchungen eine gewünschte Wasserprobe aus bestimmter Tiefe einwandfrei zu erhalten, liess sich bisher in den meisten Fällen nicht ganz erfüllen. Zum Teil gewährleistete die Konstruktion der Apparate keine einwandfreie Wasserprobe, zum Teil verhinderte die leichte Bauart der Apparate selbst die einwandfreie Entnahme einer Probe. So hat sich der in der Süsswasserforschung gebräuchlichste Entnahmeapparat für Wasserproben aus der Tiefe, der Abschlagapparat von Sclavo-Czaplewski, nach Untersuchungen von K. Gramm und H. E. Klie (1936) wegen seiner zu leichten Bauart in der Ostsee nicht bewährt. Durch die Strömung trieb er vom eigentlichen Entnahmeort derart weit ab, dass durch den hierdurch verringerten Neigungswinkel des Halteseils sehr häufig das Ampulleneinflussrohr

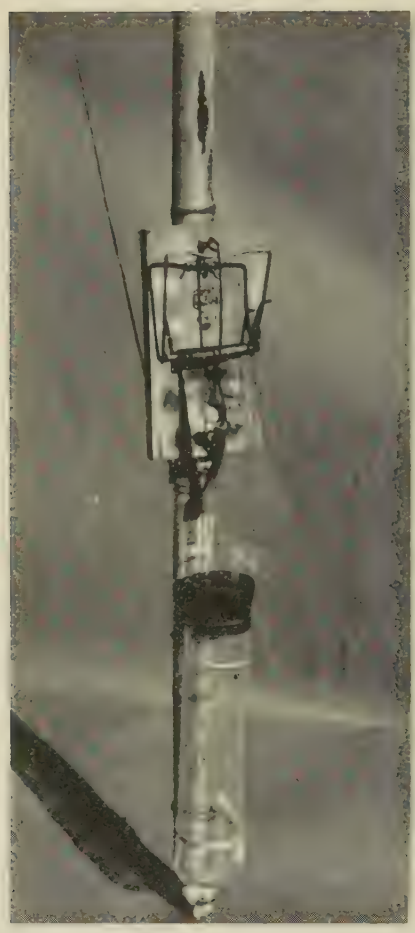


Abb. 1.

Abb. 2.

Abb. 1. Tauchfertiges Versuchsmodell eines Schöpfgefässes mit offenem Wassereinströmungsrohr für Vorversuch. Die Feder der Schliessvorrichtung ist gespannt und kann von der Wasseroberfläche aus mittels Zugleine ausgelöst werden.

Abb. 2. Das Schlauchstück des Wassereinströmungsrohres wurde durch Auslösen der Feder in 5 m. Tiefe zugequetscht, sodass beim Hochziehen des Schöpfgefässes kein Wasser entweichen konnte. Die beim Herablassen eingedrungenen Wassermengen sind deutlich sichtbar.

durch das Fallgewicht nicht zertrümmert wurde. Der "Taucher" nach W. Kruse erwies sich in seiner Konstruktion für Proben zu bakteriologischen Untersuchungen aus den Tiefen der Ostsee ebenfalls als ungeeignet, da ein Abflammen des Flaschenhalses und der Flaschenhalshaltevorrichtung, sowie das Auswechseln des Zellstoffpfropfens gegen einen sterilen Gummipfropfen an Bord bei Wind und Seegang nicht einwandfrei möglich war.

Am besten bewährte sich bisher der Wasserschöpfer nach Birge,

Abb. 3. Beim Lösen der Feder spritzte das eingeschlossene Wasser unter Druck aus dem Schöpfgefäss. Dieser Vorgang vollzog sich beim 1. Vorversuch *unter Wasser*, als das Schöpfgefäss mit offenem Wassereinströmungsrohr aus der Tiefe an die Wasseroberfläche gehoben wurde.

der von Richter modifiziert in zwei Ausführungen angefertigt und von K. Gramm und H. E. Klie in der Ostsee zur sterilen Entnahme von Tiefenproben verwendet wurde.

Das Birge-Richter-Entnahmegefäss hat aber den Nachteil, dass das Wassereinströmungsrohr beim Eintauchen des Wasserschöpfers unter die Wasseroberfläche offen ist und ohne Kappung des Luftaustrittsrohres bereits Wasser aus den oberen und mittleren Schichten durch eigene Druckkraft eindringt, noch ehe der Wasserschöpfer seine Bestimmungstiefe erreicht hat. H. E. Klie schreibt zwar: "Das Eindringen des Wassers ohne Kappung des Luftaustrittsrohres war bei

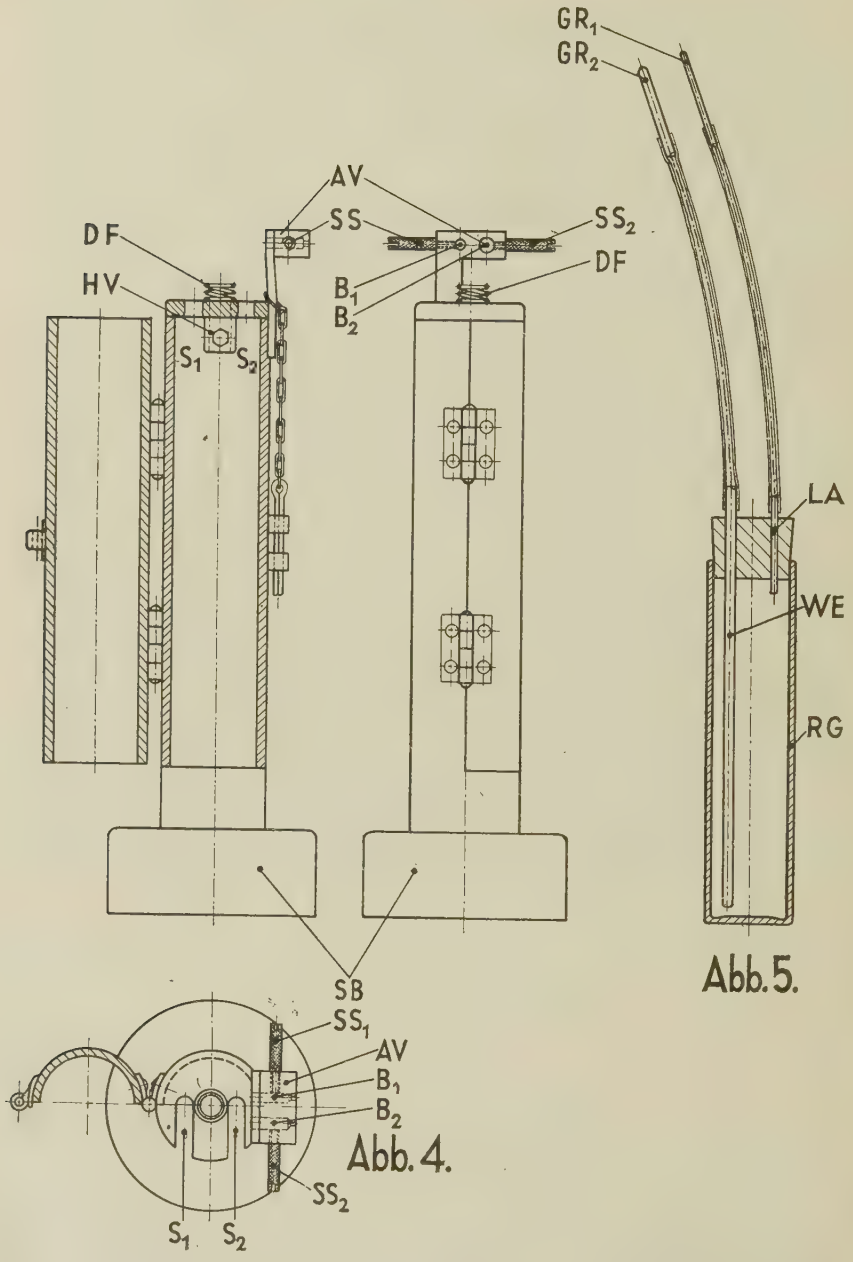


Abb. 5.

Abb. 4.

Abb. 4. Tauchapparat: SB = Senkblei; S_1 S_2 = Schlitze; HV = Aufhängevorrichtung; AV = Abschlagvorrichtung; B_1 B_2 = Bohrungen für Glasrohrstutzen GR_1 GR_2; SS = Stellschraube; DF = Druckfeder.

Abb. 5. Probeentnahmegefäss: WE = Wassereinströmungsrohr; LA = Luftaustrittsrohr; RG = Röhrenglas.

den Tiefenproben (ca. 20 m.) gering, sodass man diese Menge Oberflächen- und Mittelwasser bei den Tiefenproben nicht zu berücksichtigen braucht". Bei grösseren Entnahmetiefen hält es H. E. Klie für zweckmässig, auch für das Wassereinströmungsrohr eine analoge Abschlagvorrichtung auf der anderen Seite zusätzlich anzubringen.

Dieser Vorschlag veranlasste mich, einen Wasserschöpfer zu bauen, der eine einwandfreie Probeentnahme aus beliebiger Tiefe gewährleisten sollte.

Zunächst stellte ich Vorversuche an mit folgender Versuchsanordnung: am dicken Ende eines starken, 7 m. langen Bambusrohres wurde ein Röhrenglas von 350 cm^3. Inhalt befestigt (Abb. 1). Das Glas wurde mit einem Gummipfropfen fest verschlossen. Durch den Pfropfen waren zwei Glasrohre gesteckt. Das stärkere Wassereinströmungsrohr schnitt 0·5 cm. über dem Boden des Röhrenglases ab. Dem über dem Pfropfen vorstehenden oberen Teil des Glasrohres war ein Stück Gummischlauch übergeschoben. Das dünnere Glasrohr (später mit "Luftaustrittsrohr" bezeichnet) schnitt mit dem unteren Rand des Gummipfropfens ab und war oben zugeschmolzen, damit die im Röhrenglas befindliche Luft nicht entweichen konnte. Dadurch sollte ein Eindringen grösserer Wassermengen beim Herablassen des Schöpfgefässes bis zum Eintreffen in seiner Bestimmungstiefe vermieden werden.

Diese Apparatur wurde beim 1. Vorversuch mit offenem Wassereinströmungsrohr in eine Wassertiefe von 5 m. herabgelassen. Mit offenem Wassereinströmungsrohr an die Oberfläche zurückgebracht, enthielt das Schöpfgefäss *6 cm^3. Wasser.* Der Meniskus des eingedrungenen Wassers reichte bis zum unteren Ende des Wassereinströmungsrohres.

Beim 2. *Vorversuch* wurde in der Bestimmungstiefe der Gummischlauch des Wassereinströmungsrohres durch Auslösen einer starken Feder von einer Rattenfalle zugequetscht (Abb. 2). Hierdurch wurde beim Hochziehen des Schöpfers ein Entweichen des Wassers, das in der Zeit von Beginn des Eintauchens bis zum Eintreffen des Schöpfgefässes in seiner Bestimmungstiefe durch den Wasserdruck in das Gefäss eingedrungen war, verhindert. Die Tauchzeit des Schöpfgefässes von der Wasseroberfläche bis in eine Tiefe von 5 m. betrug 5 Sekunden. Nach dem Hochziehen befanden sich in dem Röhrenglas *60 cm^3. Wasser,* die in 5 Sekunden beim Herablassen in das Gefäss eingedrungen waren. Beim Lösen der zugeschlagenen Feder (Abb. 3) spritzte das Wasser unter Druck aus dem Gummischlauch des Wassereinströmungsrohres.

Aus den beiden Vorversuchen geht hervor, dass beim Herablassen des Wasserschöpfers durch den zunehmenden Wasserdruck beträchtliche Mengen Oberflächen- und Mittelwasser durch das offene Wassereinströmungsrohr in das Gefäss eindringen, die dann wieder beim Hochziehen durch die Expansionskraft der komprimierten Luft im Röhrenglas durch das Wassereinströmungsrohr entweichen, wie es beim 1. Vorversuch der Fall war. In 5 m. sind die bis dahin eingedrungenen Wassermengen, selbst bei raschem Herablassen des Schöpfgefässes, schon sehr gross. Bei einer Probeentnahme aus einer Tiefe von z. B. 20 m. dürften die eingedrungenen Wassermengen immerhin so beträchtlich sein, dass sie nicht mehr unberücksichtigt bleiben können. Es verlohnt sich deshalb, eine kurze Beschreibung eines Apparates, der im Prinzip des Schöpfmechanismus den gebräuchlichen Entnahmegefässen gleichkommt und sich bei Untersuchungen in der Helgoländer Rinne in Tiefen bis zu 50 m. sehr gut bewährt hat, zu veröffentlichen.

Die Konstruktion des Apparates ist aus den Abbildung 4 u. 5, sowie den Fotografien (Abb. 6—8) ersichtlich und mag noch durch folgende Beschreibung erläutert werden. Der Wasserschöpfer setzt sich aus 3 Teilen zusammen: dem Tauchapparat mit Aufhänge- und Abschlagvorrichtung, dem auswechselbaren Probeentnahmegefäss und dem Fallgewicht.

Der *Tauchapparat* (Abb. 4) besteht aus einem eisernen Hohlkörper

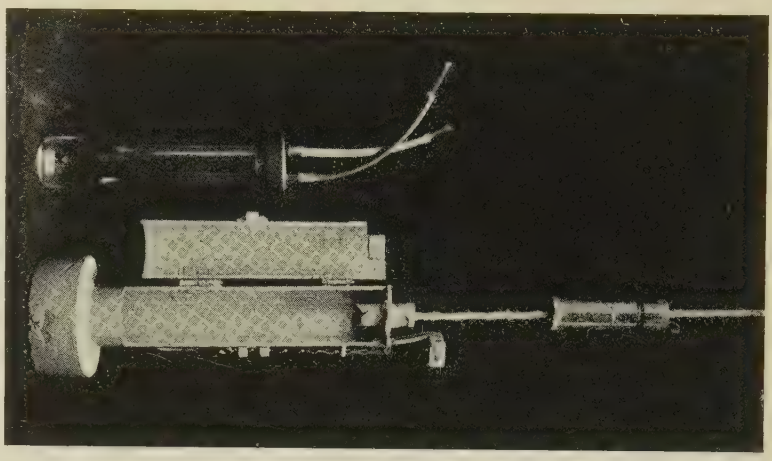


Abb. 6. Tauchapparat mit geöffneter Tür. Das auswechselbare Probeentnahmegefäss nebenanstehend.

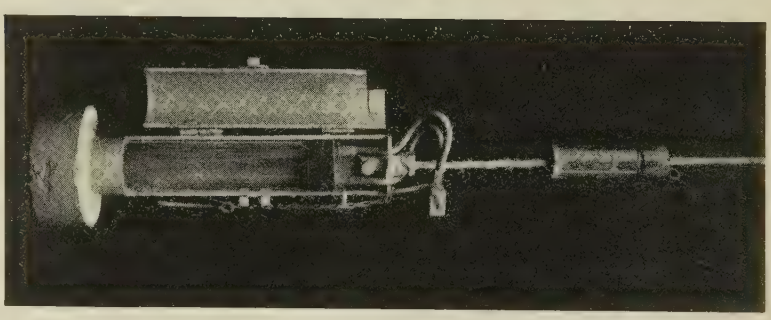


Abb. 7. Tauchapparat mit gebrauchsfertig eingesetztem Probeentnahmegefäss.

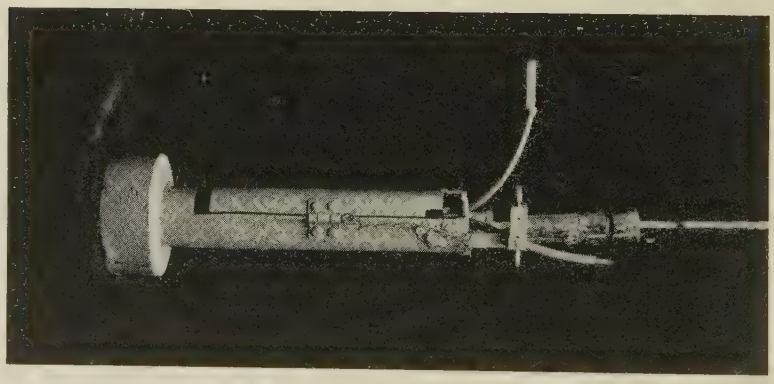


Abb. 8. Wasserschöpfer in Betrieb nach Kappung des Wassereinströmungs- und Luftaustrittsstutzens.

von zylindrischer Form, der mit seinem basalen Teil in einen zylindrischen Senkbleikörper SB eingelassen ist. Dieses Etui ist aus einem 6 cm. im Durchmesser starken Eisenrohr hergestellt, das $^4/_5$ seiner Länge in der Mitte aufgesägt wurde. Die vordere Rohrhälfte ist zu einer Tür ausgearbeitet und durch zwei Scharniere drehbar an der

hinteren Rohrhälfte befestigt. Dem oberen Ende der hinteren Rohrhälfte ist ein, in der Mitte durchbohrtes Deckelstück mit zwei nach vorn offenen Schlitzen S_1 und S_2 aufgeschweisst. Das Deckelstück trägt die Aufhängevorrichtung HV des Tauchapparates. Dies ist ein kleines, auf der Unterseite des Deckels aufgeschweisstes Messingrohr mit einer Bohrung senkrecht zur Längsachse, durch die eine Schraube mit Mutter und Gegenmutter gesteckt ist. An dieser Durchsteckschraube wird das Halteseil des Wasserschöpfers befestigt. Seitlich am oberen Ende des Eisenetuis ist die Abschlagvorrichtung AV angebracht. Sie besteht aus einem Messingstück mit rechteckigem Querschnitt, das auf einem rechtwinkeligen, 5 mm. starken Eisenplättchen aufgeschweisst ist. Die Abschlagvorrichtung ist auf der Längsseite mit 2 parallel zueinander angeordneten Bohrungen B_1 und B_2 versehen. Senkrecht zu diesen Bohrungen ist auf jeder Schmalseite der Abschlagvorrichtung eine kleinere Bohrung mit Feingewinde für die Stellschrauben SS vorhanden. Auf dem Deckel oberhalb der Aufhängevorrichtung ruht eine Druckfeder DF, die den Stoss eines herabfallenden Fallgewichtes auffängt.

Die *Probeentnahmegefässe* (Abb. 5 u. 6) bestehen aus weitlumigen Röhrengläsern RG von etwa 300—350 cm^3. Inhalt, die allseitig gegen Stoss geschützt und leicht auswechselbar in das oben beschriebene Eisenetui eingesetzt werden. Sie sind durch Gummipfropfen verschlossen, durch die zwei verschieden starke Glasrohre gesteckt sind. Das grössere, 6 mm. starke Wassereinströmungsrohr WE reicht nahezu bis zum Boden des Röhrenglases und lässt das zu untersuchende Wasser eintreten. Ein dünneres, 3 mm. starkes Luftaustrittsrohr LA schneidet 1 cm. unter dem Gummipfropfen ab und lässt die verdrängte Luft austreten. Beide Glasröhren ragen 3 cm. über dem oberen Pfropfende hervor. Sie sind durch etwa 20 cm. lange elastische Gummischlauchstücke jeweils mit 5 cm. langen einseitig zugeschmolzenen Glasrohrstücken GR_1 GR_2 von entsprechender Stärke verbunden.

Vor der Probeentnahme wird das vorher sterilisierte Probeentnahmegefäss in das Eisenetui gestellt. Dabei werden die Gummischläuche vom Wassereinströmungs- und Luftaustrittsrohr durch die nach vorn offenen Schlitze S_1S_2 des Deckels geschoben und ihre zugeschmolzenen Glasrohre werden in die entsprechenden Bohrungen B_1B_2 der Abschlagvorrichtung AV gesteckt und mittels der Stellschrauben SS_1 u. SS_2 festgeklemmt (Abb. 7). Mit verschlossener Türe wird dann der Wasserschöpfer am Drahtseil einer Winde, welches über ein Zählrad läuft, in die gewünschte Tiefe versenkt. Sobald der Wasserschöpfer seine Bestimmungstiefe erreicht hat, wird ein *Fallgewicht* nachgeschickt. Dieses trifft auf die rechts und links am Führungsseil (Abb. 7) vorbeilaufenden Glasrohrstutzen des Wassereinströmungs- und Luftaustrittsrohres, die in der Abschlagvorrichtung festgeklemmt sind, und kappt diese an der mit einem Diamanten vorgeritzten Stelle ab. Durch die Elastizität der Gummischläuche werden die jetzt freien Enden der abgekappten Glasrohrstutzen vom Wasserschöpfer weggeschleudert (Abb. 8) und das Wasser strömt durch die besondere Anordnung des

Wassereinströmungs- und Luftaustrittsrohres durch seine eigene Druckkraft in das Entnahmegefäss. Die in den Bohrungen der Abschlagvorrichtung steckengebliebenen Überreste der abgekappten Glasrohrstutzen werden durch etwas engere Bohrungen hindurch, die in ihrer Achse auf die der Hauptbohrungen B_1 B_2 treffen, mittels einer Metallnadel entfernt. Der gesamte Wasserschöpfer ist 10 kg. schwer. Das Gewicht des zugehörigen Fallgewichtes beträgt 0·75 kg.

Der Apparat bewährte sich bei den meeresbakteriologischen Untersuchungen in der Helgoländer Bucht sehr gut und arbeitete in einer Tiefe von 45—50 Metern in der Helgoländer tiefen Rinne bei Wind und Seegang einwandfrei. Es ist natürlich Voraussetzung, dass das Röhrenglas fehlerfrei ist und seine Wandstärke mindestens 2 mm. beträgt. Das Auswechseln der Röhrengläser erfolgt wegen der einfachen Konstruktion des Apparates sehr rasch. Da die Handhabung nicht umständlich ist und die Probeentnahme nur wenig Zeit in Anspruch nimmt, ist es leicht möglich, an ein und derselben Stelle nacheinander aus verschiedenen Tiefen Proben zu entnehmen. Dieser Apparat hat noch den Vorteil, dass die Glasapparatur mit Zubehör immer wieder verwendet werden kann. Es brauchen nur die abgekappten Glasrohrstutzen, wenn sie durch wiederholtes Zuschmelzen zu kurz geworden sind, erneuert zu werden.

Beim Sterilisieren wird die komplett zusammengebaute Glasapparatur mit 3 cm^3. *Aqua dest.* gefüllt und in den Dampftopf gestellt. Dabei bleibt während der Sterilisierung der Luftaustrittsrohrstutzen offen. Erst nach erfolgter Sterilisierung wird letzterer zugeschmolzen.

Schriftenverzeichnis.

Benecke, W. "Bakteriologie des Meeres", in Abderhaldens Handbuch d. biol. Arb. Meth. Abt. IV, Teil 5.

Gramm, K. "Die Kieler Bucht als Vorfluter städt. Abwässer", Kieler Meeresforschungen Bd. 1, 1936.

Klie, H. E. "Der Nachweis von Keimen der Art Bacterium coli und deren Formen in der Kieler Bucht." Dissertation, Kiel 1936.

Ohlmüller-Spitta. "Untersuchung und Beurteilung des Wassers und Abwassers." Berlin, Springer 1931.

Splittgerber-Wolfen, A. und E. Nolte. "Untersuchung des Wassers", in Abderhaldens Handb. d. biol. Arb. Meth. Abt. IV, Teil 11.

International Passamaquoddy Fishery Investigations.

By

A. G. Huntsman,
Biological Board of Canada.

THE proposal to install tidal dams for developing power at the mouth of Passamaquoddy Bay on the boundary between the Canadian province of New Brunswick and Maine, one of the United States of America, raised the question as to the probable effect on the fisheries of such a major change in the local water movements. In January 1928 this matter was brought before the Royal Maritime Fish Commission of Canada and the opinion was expressed that serious effects were to be expected on the very large fishery for small herring, the focal point of which was the locality where the dams were to be installed (Huntsman, 1928).

In June 1928 the matter was considered by the North American Council on Fishery Investigations and at the request of the Canadian Government the Council undertook to report upon the matter. A committee studied the question and reported its opinion that there would be almost complete elimination of the herring fishery inside the dams, but that fuller investigation would be necessary for any forecast on the effects outside the dams. Finally in 1931 on the initiative of the United States, the governments of the two countries acted upon the recommendations of the Council by appointing an International Commission and by furnishing funds for a two years investigation of (1) the herring, (2) the zooplankton, (3) the phytoplankton, and (4) the hydrography. It had been pointed out by the Council that the problem involved was extraordinarily complex and might not be solved in two years of intensive investigation. It was affirmed that in any event the results would have great value from the purely fisheries standpoint. (N. Amer. Coun. 1932).

The field work of the investigations extended from July 1931 to October 1932 and the scientific personnel consisted of Dr. E. E. Watson, Queens University, Canada, hydrographer; Dr. H. H. Gran, Oslo University, Norway, phytoplanktologist, with Mr.

T. Braarud as assistant; Mr. Michael Graham, Fisheries Laboratory, Lowestoft, England, ichthyologist; and Dr. C. J. Fish, Buffalo Museum of Science, U. S. A., zooplanktologist (also executive secretary) with Dr. M. W. Johnson as assistant. It was recognized that the problem required the study not only of conditions in the Quoddy region, but also of those in the Bay of Fundy and even to a considerable extent of those in the Gulf of Maine, of which the Bay of Fundy is a branch. In October 1933 the Commission submitted to the two governments the report of its investigators to the following effect:— It was not expected that the physical effects of the installation of the dams would extend far into or beyond the Outer Quoddy region (outside the dams). It was not considered that the dams would have an appreciable effect upon the production of plant life outside the Quoddy region. The rich fishery was not due to local abundance of zooplankton, and the supply of the latter forming the food of the herring was considered to be brought into the region from outside areas beyond the influence of the dams. For a sure forecast of the effect on the fishery more investigation would be required, but no way was foreseen by which the Outer Quoddy region or the Bay of Fundy would be made less favourable for the herring which were produced beyond the influence of the local conditions. The effect upon the availability of the herring was likely to be considerable, but was not a serious one out as far as Grand Manan and not likely to occur along the coast of Maine. Inside the dams the herring fishery would almost certainly be reduced to negligible proportions. (N. Amer. Coun. 1935).

Canada, for whom the herring fisheries were of chief concern, did not consider the report sufficiently reassuring to warrant support of the international power project, so that the latter did not proceed. There had, however, been an alternative plan, of only one-quarter the magnitude of the main one and with the construction confined to the United States side of the region. It involved the damming of Cobscook Bay merely, instead of both Passamaquoddy and Cobscook bays. The North American Council had considered this in 1929 and reported its opinion that such a limited project was not expected to cause any serious and widespread damage to the fisheries. In 1935 the Government of the United States undertook to carry out this lesser project and spent $ 6,363,000.00 in more or less preliminary work without actually installing the dams. Failure to secure further funds resulted in the abandonment of the enterprise in 1936, and at the present time there seems no prospect that the project will ever be completed. From an experimental standpoint this is regrettable, since by following the effects of the damming of Cobscook Bay it would be possible to predict more surely the results that would follow the damming of Passamaquoddy Bay.

From the standpoint of science and the fisheries, the important results are those contained in the four main articles that have appeared during the last two years and that are based upon full study of the

material secured in 1931—1932. According to plan they deal with the phytoplankton (Gran and Braarud, 1935), the herring (Graham, 1936), the hydrography (Watson, 1936), and the zooplankton (Fish and Johnson, 1937). Their chief significance may be considered to lie in the fact that they represent a precise and intensive attempt to relate a fishery to the physical conditions. The fishery is predominantly one for small herring to be canned as "sardines". These are taken in fixed traps or weirs, and from the Canadian

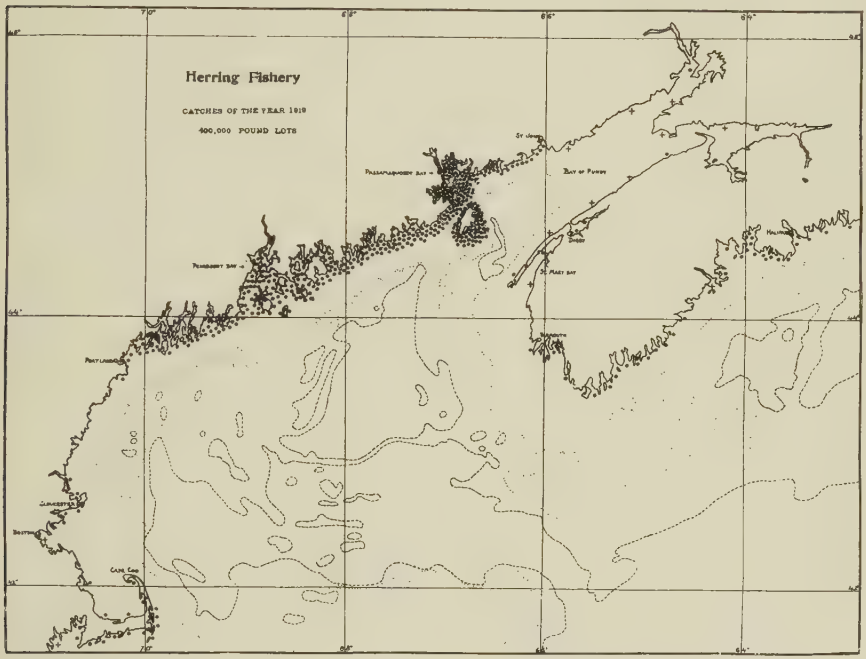


Figure 1. This chart (reproduced by the courtesy of the Biological Board of Canada) was constructed by placing dots opposite each county according to the weight of herring (including sardines) landed in 1919 (information from official U.S. and Canadian statistics).

portion of the Quoddy region over 75,000,000 pounds were taken in 1911, the peak year. In Figure 1, which is for the year 1919, it will be seen how the greatest concentration is in this region, and in Figure 2 it will be evident that there is a particular concentration of the most successful weirs in the middle of the region, the vicinity of Letite passage. The problem was to determine to what extent this fishery would be affected by a definite change in the physical conditions and this necessarily involved a study of the possible relations of this fishery to peculiar local conditions. The region is essentially a "drowned" coast, chiefly characterized by an archipelago, between the islands of which are passages that tend to be deep and tortuous, with irregular rock bottom. The archipelago is on one side of the mouth of the

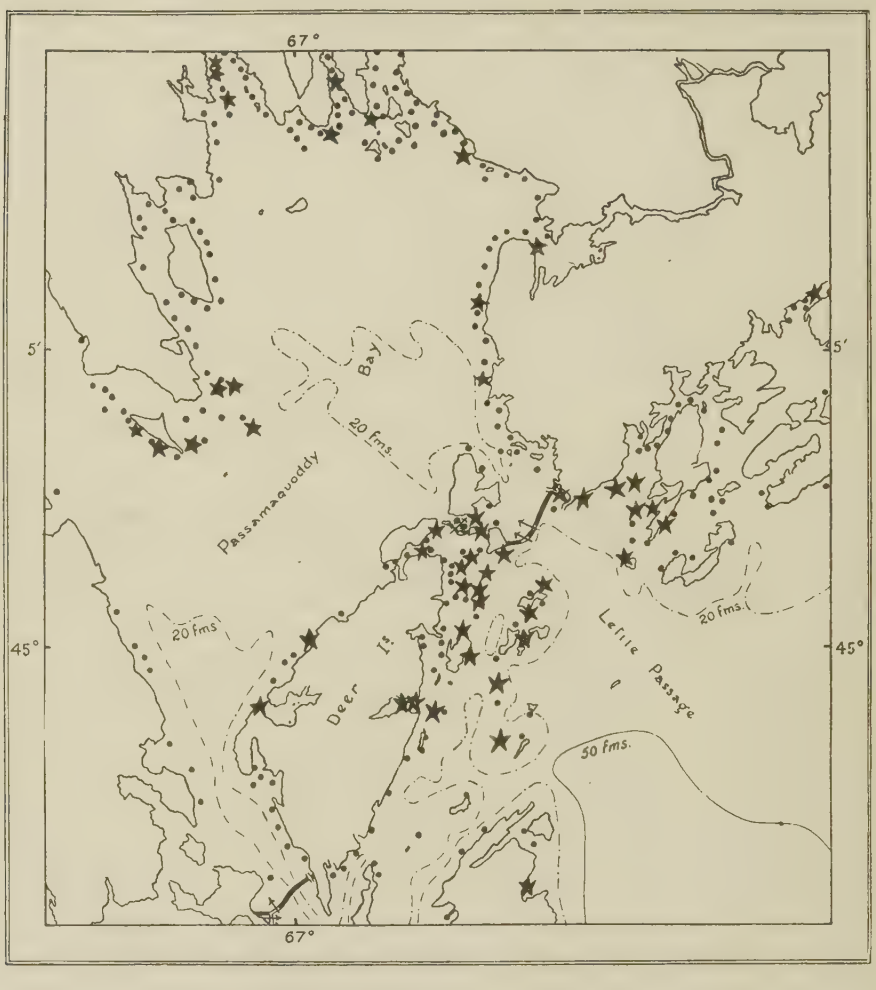


Figure 2. Location of best weirs. Sardine weirs operated in recent years are shown as black dots. Those of best reputation are shown with stars. Three Inspectors of Fisheries gave this information, for districts meeting in Letite passage and it is remarkable how the stars are close to that passage, demonstrating its preponderant richness. This is close to the main tide and deep water, and the coast is highly indented and irregular.

funnel-shaped Bay of Fundy and largely blocks the broad mouths of Passamaquoddy and Cobscook bays. Roughly a third of the fresh water entering the Gulf of Maine and at the same time two-thirds of that entering the Bay of Fundy, is related to the Passamaquoddy region. Most of this comes from the Saint John River, which discharges into the Bay of Fundy a short distance to the east, but a significant amount is discharged directly into Passamaquoddy Bay. The average amount is around 37,000 cubic feet per second, and this is nearly tripled during

April and May, the months of chief discharge. A tidal range of from 20 to 25 feet results in very efficient mixing of the water, in relation both to the rough shoals and to the irregular passages.

The Results.

The results of the hydrographic investigations (Watson, 1936, review in Journ. du Cons. XII, 3, p. 340) show the character of the water and of the mixing that occurs. The water issuing from the Saint John estuary is strongly stratified; that is, the fresh water is very incompletely mixed with salt water, and flows seaward in a layer about 10 metres thick over deep homogeneous water of comparatively high salinity. It moves south-westward along the coast to the outer part of the Quoddy region and toward the island of Grand Manan at the mouth of the Bay of Fundy, a distance of 74 km., and shows little tendency to spread across the bay. By mixture with the water below it increases in volume, but it spreads out sufficiently to remain of the same depth. The additions from below make it progressively heavier, changing (as observed in the spring freshet at the beginning of May) in range in density (σ) from 16 to 25 near Saint John to 23 to 25 near Grand Manan, where it is abruptly dissipated. Its persistence for such a distance is owing to its strong stratification, that is, high density gradient, and to its passing out to sea rather abruptly, where over deep water the vertical velocity-gradient is weak and able to destroy the stratification only very slowly. The Quoddy region on one side of the Saint John water and the head of the bay on the other have smaller drainage basins (12 % and 30 % respectively of that of the Saint John) and consequently receive much less fresh water. At the same time their waters are so strongly mixed that they tend to be homogeneous from top to bottom and increase in salinity going seaward. The irregular configuration of the Quoddy region makes it a particularly difficult one to understand. The principal mixing of the fresh water with the salt occurs in the narrow passages between the Inner and Outer parts. The issuing mixed water has three possible courses before it — toward Saint John between the Wolves islands and the mainland; toward the open bay between the Wolves and Grand Manan; and toward the Gulf of Maine through Grand Manan channel. The observations indicate little interchange through the latter channel, with a small residual movement inwards, rather than outwards. The facts favour the view that the mixed water leaves the region chiefly between Grand Manan and the Wolves, which course, having the deepest water, is the one by which the deep, salt water reaches the region.

The mixing that is effective in setting up hydrodynamic forces and thus producing residual currents is measured by the work done in raising the deep, heavy water to be mixed with light surface water.

The total mixing of this nature in the Bay of Fundy is calculated as having an energy value of 24,200 kilowatts, of which 2,080 kilowatts are expended in the Quoddy passages, 640 in the Saint John estuary, and 3,400 in the head of the bay, leaving a large balance for the rest of the bay. The strong tidal currents prevent any of six possible methods of determining residual currents giving very satisfactory results. The most definite of these currents, as shown by the dynamic isobaths, are the Saint John outflow, the westerly outflow outside Grand Manan, and the inward flow on the Nova Scotian side of the bay. As a result of the mixing, two systems of movements occur and are to be found in juxtaposition in the region. Where fresh water is supplied directly to the mixing mechanism, there is merely a surface outflow and a bottom inflow, as in the region which receives the Saint John outflow. Where mixing occurs along the margin of a body of stratified water, the mixed water moves away at an intermediate depth while surface and bottom waters flow toward the place of mixing, as occurs on the Nova Scotian side of the bay.

In the phytoplankton investigations (G r a n and B r a a r u d, 1935, review in Journ. du Cons. XII, 2, p. 215), chief attention was given to the factors that determine abundance. In the Gulf of Maine, as in north European waters, the spring increase of diatoms occurs at the end of the winter overturn of the water, with a plentiful supply of phosphates and nitrates near the surface. Cold-water neritic forms appear first and spread from the coast outwards. The season develops most rapidly to the south-west and offshore, where even by the beginning of May with the temperature up and the phosphates low in amount, diatoms had nearly disappeared (from the upper layers at least) and *Ceratium* was abundant. As the season progresses this condition spreads north-eastward and to some extent shorewards. Along the coast of Maine, however, whither flows the water from the mouth of the Bay of Fundy, the productive zone is less (perhaps as little as 10 metres deep compared with 25 metres offshore), the supply of phosphates is fairly well maintained and the temperature does not rise as high. Associated with this condition, neritic diatoms continue to flourish all the summer, but there is a sequence of species as the temperature rises from 3° to 12° C. Light and nutrient salts are the factors that limit phytoplankton production in the Gulf of Maine.

In the Bay of Fundy the conditions are more complicated. As in the coastal zone outside, the productive zone is not deep (10 metres or less), the temperature fails to rise very high, and the phosphate and nitrate contents continue relatively high from surface to bottom. In correspondence with this, neritic diatoms were to be found throughout the season, but they began to develop late, produced a much poorer crop than in the Gulf of Maine, and in June the phytoplankton was extremely poor. This extraordinary condition is explained partly by the poorer light conditions (25 % less radiation than in the Gulf of Maine), but chiefly by the high degree of turbulence of the water from

the strong tidal currents, which prevents the diatoms remaining long enough in the thin, properly lighted surface layer to grow and reproduce. There was, however, much variation. Stations along the New Brunswick coast in the outflow from the Saint John estuary were the poorest and these had the most turbid water, as shown by examining the centrifuged water samples for detritus as well as by Secchi disk readings. Where the surface layer maintained greatest stability, as near the centres of bays, the growth of diatoms was best. Also in May when surface stability was comparatively high as a result of the large amount of fresh water from the spring freshet, and to some extent also in August with the stability higher as a result of the maximum temperature for the season, the phytoplankton was richer. The neritic diatoms showed some succession of species with the development of the season, while a *Ceratium* society, like that of the offshore waters of the Gulf of Maine, appeared in June near the entrance and in the centre of the bay, and became dominant there in August. On the Nova Scotian side in September there were visitors from the Atlantic, particularly oceanic coccolithophorides, in relatively great numbers.

The zooplankton investigations (Fish, 1936 a, b and c; Fish and Johnson, 1937, review in Journ. du Cons., XIII, 1. p. 118) show that in the Gulf of Maine and Bay of Fundy a relatively few boreal endemic species (all of them Crustaceans, and mostly copepods) dominate, forming from 87 to 97 % of the population over the whole area in each month from April to September, and with little variation from district to district. Of these the principal one is the copepod *Calanus finmarchicus*, which averages 35·5 % by number for the year in the Bay of Fundy and 39·9 % during the period from April to September in the whole region. While as a whole the zooplankton consists of a typical "*Calanus* community" which remains qualitatively uniform throughout the year, there is much seasonal variation and the species vary considerably in abundance in different parts of the region. Strictly local swarms of individual species are also common, e.g., of the Chaetognath *Sagitta elegans*, of the copepod *Temora longicornis*, and of the amphipod *Euthemisto compressa*.

Fluctuations in the zooplankton population as a whole are largely due to changes in the abundance of *Calanus finmarchicus*. For this species the western part of the gulf is the principal source of supply, the New Brunswick and the neighbouring Maine coasts not only having a small population but also failing to have successful reproduction. The lowest level is reached at the end of winter and in the western stock there are two well-defined breeding periods, March—April and June—July, with a possible third in September. In the eastern stock the breeding periods are a month later and two only, April—May and July—August. These broods do not remain locally, but are widely distributed by the cyclonic circulation of the water, so that the western stock is into the Bay of Fundy in considerable quantities by the time it has reached late nauplius stages. The adults

and late copepodite stages, which largely determine the volume of the zooplankton, increase in numbers rapidly from April to May and tend to decrease from May to December. The next most abundant form is *Pseudocalanus minutus*, and its progressively later spawning, from the outer gulf to the western gulf and to the Bay of Fundy make possible a distinction of three major breeding stocks. The western stock has at least three and possibly four breeding periods, March—April, May—June, July—August and September, while to the east there are only three. The western stock declines rapidly after its first brood but this one is important and widely distributed, large numbers of the nauplii reaching the Fundy region. As the Bay of Fundy and neighbouring Maine coast give no evidence of successful propagation, the outer gulf appears to be the principal source of supply after the first brood from the west. While the early larvae of this species greatly outnumber those of *Calanus*, a higher rate of mortality makes it generally much inferior to *Calanus* in numbers in its late stages. Unlike *Calanus*, the proportion it forms of the zooplankton population increases going toward the Quoddy region.

The near-shore waters of the Quoddy region and of the Maine coast have low volumes (representing average abundance at all depths) of zooplankton and the latter increase crossing to the Nova Scotian side of the Bay of Fundy and going offshore in the Gulf of Maine to deep water. The south-western portion of the gulf has the first increase in volume in the spring, but this high volume spreads to the east and into the Bay of Fundy along the Nova Scotian shore. By August the richest area is in the form of a belt along the 50-fathom contour line of the Maine coast and extending to the Nova Scotian shore of the Bay of Fundy.

The herring investigations (G r a h a m, 1936; review in Journ. du Cons. XII, 2, p. 224) dealt chiefly with the character of the fishery for the young ("sardines"), which is chiefly concentrated in the Quoddy region, and with the possible factors that are responsible for it. It was not considered possible to be certain that the very large catches of "sardines" are due to large local populations of fish. Partial explanation was seen in capture of herring being especially easy in that region, and turbidity of the water was the only physical factor found which possibly rendered the region specially attractive to the herring. Herring fry, from summer spawning, were found in September from south-west of Grand Manan, where considerable spawning occurs, across to Nova Scotia, in along its shore and across to Saint John. In December and January they were taken only on the Nova Scotian shore, and from February to April they showed very little growth and no particular change in distribution. Planktonic forms (Chaetognatha and Ctenophora) also indicated that there was very little water movement during this time, when the rivers were frozen over. There was a general scarcity of the fry in the Bay of Fundy and neighbouring waters, and particularly in the "sardine" area. They were observed near shore and in Passamaquoddy Bay

first in July and the metamorphosed herring first appear in the catches in August, when about 12 months old. The herring are generally segregated into shoals of similar length and certain areas tend to have herring of particular sizes.

Discussion.

With passing of interest in the proposed power dams, the original object of the investigations is no longer of importance. However, the problem of the causes of the remarkable local concentration of the herring catches is one of very great continuing interest from the fishery standpoint. The herring as a fish that usually occurs in very large numbers, that is somewhat local in habit, and whose food consists of planktonic forms that can be studied quantitatively with comparative ease, is particularly satisfactory for an attack on the general problem of the factors that determine abundance or scarcity of marine fish.

While it is always possible to argue with some truth that the capture of aquatic forms either by the fisherman's gear or by the refined apparatus of the scientist does not properly represent the actual abundance of the forms in the water, it cannot be doubted that, when the same method is used steadily in different places with strikingly different results, there are actually very considerable differences in the abundance of the forms. G r a h a m has emphasized the deficiencies of weirs for proper sampling of the sea, since their effectiveness depends upon such variable things as strength of tidal currents and shore topography. Such mechanical overfactors could not, however easily explain the differences in localization of herring catches and salmon catches, which are shown by the weirs. The conclusion seems to me unavoidable that the "sardine" area and in particular the Quoddy region is characterized by an exceptionally great abundance of herring. Weirs are operated all around the Bay of Fundy and, as they are fixed, operate more steadily than any other fishing gear, and take all sizes of fish from the recently metamorphosed herring or "brit" (smaller than "sardines") to large tuna, they are unrivalled for showing local and seasonal differences in the near-shore abundance of fishes. The fish are taken and their abundance known, whether or not there is any sale for them. Throughout each year, and year after year there is no district in which "sardines" are taken in anything like the numbers they are in the Quoddy region, although their local distribution in that region varies greatly from one time to another. While in other districts the herring tend to be inshore only in the summer season, and all sizes occur in each locality, the largest appearing first and the smallest latest, in the Quoddy region they are to be found near shore throughout the year (though sluggish in the winter) and there is a fairly pronounced local segregation of the sizes, grading from the smallest, the "brit", inland in Passamaquoddy and Cobscook bays to the largest, the spawners, just outside Grand Manan. In spite of the large numbers removed from the water there is no place where anything like so

many herring are to be seen, feeding in the tide rips, or crowded against the shore when pursued by their enemies. The fishermen take advantage of this whenever they are permitted to do so (or can escape detection by the fishery patrol officers) to "torch", "drive" or "dip" them, using a torch at night and capturing them in large dip-nets from small boats. The small herring were at first used only in very small quantities for bait and for manure for the land, but from 1865 to 1880 an intensive fishery for them developed, at first as a source of oil and fertilizer ("guano"), but later for canning as "sardines". Prior to this time the fishermen's efforts were concentrated on taking the fairly large sexually immature herring, two to three years old, known as "stringers" and used for producing a hard smoked article, and no other district yielded so many. Also the fattest large immature herring known, the famous Quoddy herring, were taken in the centre of the region. In spite of intensive fishery for the immature, there was no place along the Atlantic coast from Cape Breton to Cape Cod where so many large spawning herring were to be found and were captured as on the outer side of Grand Manan. At the same time fishermen were able to develop a big fishery with gill-nets in winter for the recovering spent fish, which were to be found in the "sardine" area from Saint John to Grand Manan, but not elsewhere. With the development of an intensive fishery for "sardines", the Quoddy herring, and the winter herring became so few that the fisheries for them utterly failed, and the quantities of "stringers" and spawners became much reduced. Nevertheless no other district produces anything like the quantities of "stringers" that continue to be removed yearly from the Quoddy region, and the spawning grounds outside Grand Manan continue to have a greater concentration of large fish than any other place along the coast. The evidence is overwhelming that no other district can compare with the Quoddy region and the associated Grand Manan region for abundance of herring from the "brit" stage to the spawners.

With such a concentration of young herring in the region, it would be, and was, expected that clearly favourable conditions for the herring would be revealed by investigation. Either there would be suitably located good spawning grounds with a very plentiful supply of food for the young from the larval stage on, or at the least it would be an exceptionally rich feeding ground to which the young would resort for food during the period of rapid growth in their early years. On the contrary careful, thorough and comprehensive work by a most competent corps of investigators has revealed almost the very opposite condition. The results of previous studies have been confirmed and greatly extended to give the following picture, on which I believe we can thoroughly rely. There is no spawning in the Quoddy region, and, although an exceptionally important spawning ground is located just outside it at the southern end of Grand Manan island, there is a quite definite residual current to carry the larvae as they rise in the water south-westward away from the region rather than toward it.

Until the close of their first year of life the young are virtually absent from the region. While there is never any lack of nutrient salts in the water, the latter's great turbidity makes the surface layer effective for phytoplankton growth very thin, the almost constant overturn of the water tends to prevent the phytoplankton from remaining near the surface a sufficiently large proportion of the time to permit growth and reproduction, and the general fogginess of the region significantly decreases the amount of light available for plant growth. For these reasons there is a very poor start in the food chains leading to the herring. As an almost necessary result, such herring food as there is in the region for the most part comes from outside districts and its abundance is low and graded to those districts. The residual currents that might be expected to bring and concentrate both the young herring and their food in the region are, when most definite, circulatory in nature and flow past or from the region to an even greater extent than they flow towards it.

It is quite clear that we have here a problem that current fundamental knowledge, current theories, and current investigational technique have been powerless to solve. The investigations may have been very well worth while if they merely bring into sharp relief the deficiencies in our equipment for successful attack on the all important problem presented by varying abundance of fish. Can we at all see what these deficiencies are? We have other arresting facts than the unexpected concentration of herring. While, as Fish and Johnson (1937) show, the abundance of zooplankton in the region is low as judged from stations in the basins, there is, as has been so well described and figured by Graham (1936), a wealth (as compared with other districts) of deep-water planktonic forms, such as Euphausiids, *at the surface* in the tide rips of the centrally placed passages. As a result very large flocks of birds — gulls, terns, and phalaropes — depend upon them for food. Sometimes the Euphausiids are cast upon the beaches along the passages in such quantities as to be hauled away in wagon loads for manure (Battle *et al.*, 1936). This is a feature of the region that has been most frequently commented upon by visiting biologists. While the surface occurrence of these deep-water forms is quite regular, their abundance fluctuates very greatly. Also, in spite of their forming the focal point in the abundance of the young herring, the Quoddy passages are reputed to have the fattest herring and investigation has fully corroborated this (Battle *et al.*, 1936).

Another point concerns the residual currents. From hydrographic measurements it is concluded (Watson, 1936) that these currents go past the region. Yet of drift-bottles set free in the outer part of the region, on its margin, or well outside it even to 150 miles distant, almost as many (18) entered or penetrated the region (one even going to the very head of Passamaquoddy Bay) as went (20) to the Maine coast outside the region whither the definite residual currents would be expected to carry them (see Fish and Johnson, 1937). It is also

noteworthy that more of the bottles (50) were retaken in the "sardine" area from Saint John south-westward to Grand Manan and along the Maine coast than were retaken on the Nova Scotian shore (48) whither the prevailing winds of summer would be expected to carry them and set them ashore. And of the latter over half were retaken in the subsidiary "sardine" area from St. Mary Bay to Annapolis basin. There must be considerable surface movement into the region and into the turbulent "sardine" area in general.

It seems incontrovertible that the young herring are in the centre of the region in exceptionally great numbers and obtain sufficient food to become very fat. As neither herring nor food are produced locally they must go or be carried there. The investigations have failed to reveal any reason such as food why they should go there. There are good reasons for believing that not only the zooplankton but also the herring are rather definitely determined in their distribution through passive transportation by currents (Huntsman, 1934). If this be so, the problem resolves itself into a matter of precise behaviour of the herring and of the most important forms in the zooplankton, which would affect their transportation by the currents, as well as of the precise character of the various water movements that would shift these animals. Both of these are extremely complicated. From the physical standpoint the determination of the possibly significant movements of the water in the Quoddy region presents an almost impossible task, but I believe a beginning has been made in the demonstration of two of the simpler types of differential movements of the water layers (Watson, 1936) as the result (1) of mixing at a point of freshwater outflow and (2) of mixing alongside a supply of stratified water. These occur in the region in rather pronounced form, and there are doubtless others still more complicated. Their effects on the distribution of the plankton and of the herring will vary with the depth at which the various forms occur, which itself varies not only from form to form, but with differences in size and even sex, and in relation to varying conditions of the environment, perhaps chiefly light. Only a beginning has been made in this direction of attack on the problem, but the results already attained are definitely promising. It is perhaps of significance that the "sardine" area is abruptly limited at its up-current end by the Saint John outflow, the most pronounced freshwater influence along the whole coast, and that the greatest concentration of the herring, from the "brit" of the inner bays to the spawners outside Grand Manan, is across the abrupt seaward termination, as a distinct entity, of this same outflow. It is the freshwater that, when associated with varied mixing in the sea, gives such complicated differential movements of the water layers. Effectiveness in mixing should probably be measured, not by the energy required to raise the salt water, but by the amount of salt water actually incorporated with the fresh.

References.

Battle, H. I., A. G. Huntsman, A. M. Jeffers, G. W. Jeffers, W. H. Johnson and N. A. McNairn. Fatness, digestion and food of Passamaquoddy young herring. J. Biol. Bd. Canada, *2* (4) 401—429, 1936.

Fish, C. J. The biology of *Calanus finmarchicus* in the gulf of Maine and bay of Fundy. Biol. Bull., *70* (1) 118—141, 1936 a.

The biology of *Pseudocalanus minutus* in the gulf of Maine and bay of Fundy. Biol. Bull., *70* (1) 193—216, 1936 b.

The biology of *Oithona similis* in the gulf of Maine and bay of Fundy. Biol. Bull., *71* (1) 168—187, 1936 c.

Fish, C. J. and M. W. Johnson. The biology of the zooplankton population in the bay of Fundy and gulf of Maine with special reference to production and distribution. J Biol. Bd. Canada, *3* (3) 189—322, 1937.

Graham, M. Investigations of the herring of Passamaquoddy and adjacent regions. J. Biol. Bd. Canada, *2* (2) 95—140, 1936.

Gran, H. H. and T. Braarud. A quantitative study of the phytoplankton in the bay of Fundy and the gulf of Maine (including observations on hydrography, chemistry and turbidity). J. Biol. Bd. Canada, *1* (5) 279—467, 1935.

Huntsman, A. G. The Passamaquoddy bay power project and its effect on the fisheries. 1—45, Saint John, N.B., 1928. Herring and water movements. James Johnstone Mem. Vol., 81—96. Liverpool, 1934.

North American Council on Fishery Investigations. Proc. 1921—1930, No. 1, Ottawa, Canada, 1932. Proc. 1931—1933, No. 2, Ottawa, Canada, 1935.

Watson, E. E. Mixing and residual currents in tidal waters as illustrated in the bay of Fundy. J. Biol. Bd. Canada, *2* (2) 141—208, 1936.

Migrations of Small Halibut Marked in Faroese Waters.

By

Å. Vedel Tåning,

Copenhagen.

FOR a number of years now the Danish research-vessels have been carrying out marking experiments on halibut at the Faroes, Iceland and Greenland when opportunity permitted. Few large halibut were marked and returns of these have been very scarce.

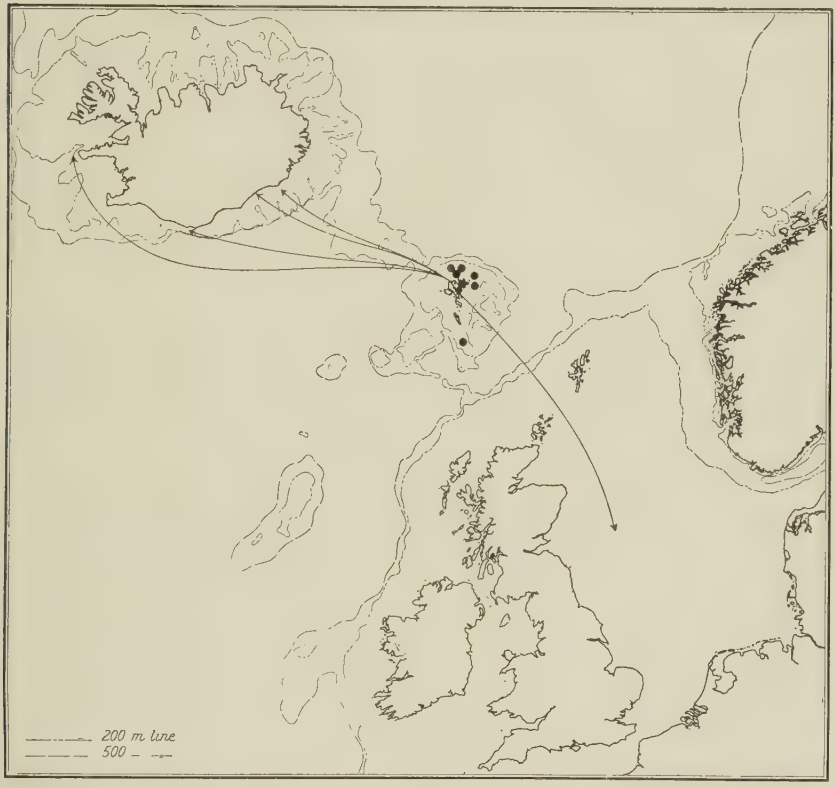
One of the experiments, however, with *young* halibut at the Faroes in 1937, has yielded some remarkable results and I think it worth while publishing this purely preliminary note about them.

Marking experiments on halibut have not been mentioned up to the present in the literature dealing with *Atlantic* waters; but just as this report was being written, information was received regarding some interesting marking experiments made from the Norwegian side by Thor Iversen and Finn Devold[1]). The experiments were carried out partly at Bear Island (315 marked), partly in the fjords of northern Norway (97) and on Röst Bank off that coast (88); it is mentioned further that 25 specimens of 70—205 cm. in length were marked at the Faroes in 1937, but without obtaining so far any recaptures. So far as one can gather from this work, the experiments were made on fish which were almost all over 60 cm. in length. The interesting experiments at Bear Island show a migration of 4 specimens to North Norway, where a stock of spawning halibut has been discovered recently inside the fjords. The experiments in the fjords (Glåmfjord and Sørfolla) have not shown wide dispersion, nor have the experiments made on Röst Bank; so far no movements over 65 miles have been recorded.

On the other hand, the *Pacific* halibut, as is well known, has been the object of a long series of extremely interesting experiments carried out by William F. Thompson; in these altogether 10,907 fish

[1]) Finn Devold: The North Atlantic Halibut and Net Fishing. (Fiskeridirektoratets Skrifter, Vol. V, No. 6. Bergen, 1938).

were marked and no less than 2,186 were retaken before the results of the experiments were published[2]). These experiments were also carried out mainly on larger fish, very few below 60 cm. being marked. The result showed that the smaller specimens at least of the Pacific halibut do not in general undertake extensive journeys; but as mentioned, few of the halibut marked were below ca. 60 cm. In various respects, however, the Pacific halibut has proved, biologically speaking,



Migrations of Small Halibut, Faroes.
➛ recaptured outside the Faroe area;
• „ on the surrounding banks.

to be extremely different from the Atlantic form and it would hardly be right to apply conclusions regarding its behaviour at different stages of development to the Atlantic species at corresponding stages.

As we knew from the age analyses of halibut from Faroese waters[3]) that the individuals living in the fjords move out at an age of about

[2]) William F. Thompson & William C. Herrington: Life History of the Pacific Halibut. 1. Marking Experiments. Victoria, 1930.

[3]) P. Jespersen: Investigations on the Stocks of Halibut in the North Atlantic. Rapp. et Proc.-Verb., Vol. XCIX, II, pp. 4—5, 1936.

Records of Small Halibut recaptured outside the Faroe Area.

No. on label	Date and year marked	Locality of *liberation*	Locality of *recovery*	Date and year recovered	Days in the Sea	Initial and final size cm.	Age at recovery	Sex	Nationality of vessel
8413	27/7 37	Kalbak Fjord, Strømø 62°03′2 N. 6°51′2 W. 52 m.	63°20′N. 18°58′W. South Iceland ca. 100 m.	11/9 38	411	55—72	V	?	German
8416	27/7 37	Kalbak Fjord 62°03′1 N. 6°48′W. ca. 50 m.	ca. 64°05′N. 15°55′W. Hrollaugseyjar, South-east Iceland 71 m.	19/5 38	296	50—53	V	♀	Danish
8434	6/8 37	Off Lysaa, Sundene 62°16′N. 7°03′4 W. ca. 54 m.	ca. 56°35′N. 0°25′E. 115 miles NE. ½ E. of Tyne, North Sea. 70—90 m.	29/8 38	388	53—71	IV	♀	English
8436	6/8 37	Off Lysaa, Sundene 62°16′N. 7°03′4 W. ca. 54 m.	64°49′N. 24°12′W. Off Snæfellsnes, W.-Iceland ca. 80 m.	28/4 38	265	48—>53	V?	?	Icelandic
8446	9/8 37	Kalbak Fjord 62°03′3 N. 6°53′W. ca. 30 m.	64°10′N. 14°50′W. Off Stokksnes, South-east Iceland ca. 80 m.	5/7 38	330	60—?	?	?	English

3—4 years and at a size of about 45—55 cm., whilst on the other hand we had no marking experiments to show how and where these outcoming halibut travelled in the waters round the Faroes, I undertook the marking af 68 fish within the fjords there in July—August 1937. The halibut were captured in depths between 30 and 75 metres, on soft ground, by means of a lobster trawl which proved to be an admirable apparatus for this purpose, very few flatfish suffering any injury when taken in this manner. The marks were fixed in the gill-cover and were of the same type as that used for the cod (see *Journal du Conseil*, Vol. VIII, p. 385 *et seq.*, 1933).

The halibut were at once restored to the water at the spot where they were captured; some were marked in almost all the fjords and sounds. The size of the marked halibut was 38—62 cm., the majority (ca. 75 %) being between 40 and 55 cm. In the course of the first 14 months after marking no fewer than 26 % (18) of the marked specimens were recaptured. Of these 7 were retaken where they were liberated, 6 on the banks round the Faroes themselves, and, lastly, 5 were retaken right outside the Faroes area, namely, 4 at Iceland (that is, no fewer than 22 % of all recaptures) and also one in the North Sea. The accompanying chart shows the migrations of the specimens in the last two categories.

The fish recaptured in the fjords were mainly small when marked, namely 39—46 cm., with one exception at 56 cm. (average 44·0 cm.). The 6 individuals recaptured out on the bank round the Faroes were on the whole a little larger, namely, from 41—54 cm. (average 47·5 cm.). But the 5 specimens which migrated right away from the area were among the largest, namely, from 48—60 cm. (average 53·2 cm.); the appended list shows the details.

The exact time when the migration began cannot be determined from the available material, which is too small for this purpose. But it may be noted that none were retaken outside the fjords before about 1st of January, and that the fish which had made long migrations were first retaken in April to September of the following year, i.e., after the spawning period was over. Apart from this the recaptures were spread over all months of the year.

The localities where the recaptures were made had depths of between ca. 70 and 160 m.; since the fish were marked in depths between 30 and 75 m., this means that they have made for greater depths. The greatest distance travelled, from the Faroes to West Iceland, was at least 520 nautical miles; and all the far-travelled fish have covered at least 300 nautical miles. The recaptured fish show, in agreement with Jespersen's results (l.c. 1936, p. 5), that the growth of the halibut in the Faroes area is good, but somewhat variable; the greatest increment is about 18 cm. for a female in the course of one year. Both males and females have been recaptured and the males seem to grow slowest even at this size. The recaptures inside the fjords were made exclusively by Faroese fishermen (6), on the banks by Scottish (5) and English (1) boats; the far-travelled fish were recaptured

by vessels of the following nationalities: England (2), Germany (1), Iceland (1) and Denmark (1).

We may ask now: Why does such a large number of these small halibut undertake the extensive migrations revealed by this limited experiment? The answer is far from clear, and many more fish must be marked to throw light on the matter.

It is already known that the spawning grounds of the halibut within this area lie in the great bight of the Atlantic off Scotland—Faroes—Iceland, apparently in depths of ca. 1,000 metres; but the investigations *made so far* indicate that the fish discussed here were not large enough to be near the mature stage. The smallest mature or spent females known from the north-eastern parts of the Atlantic are stated to have been 127 cm. (Northern North Sea; Williamson 1911, p. 48[4]), 137 cm. (Iceland; Jespersen 1917, p. 30[5]) and 131 cm. (North Norway; Devold 1938, l.c. p. 22); in the case of males, so far as I know, the only information is that mature specimens are known down to 75 cm., though smaller may also occur (Devold 1938). Since two of the above-mentioned far-travelled fish were females (ca. 50—70 cm. in length), it could hardly be the inception of maturity which has caused them to migrate and they could not therefore have undertaken the ordinary migrations of mature halibut, out into the depths of the Atlantic and then returned to coastal areas after the spawning. Possibly, however, the size at which the Atlantic halibut become mature is too imperfectly known (especially here towards the southern boundary of the species); at any rate the experiments of W. F. Thompson in the Pacific have shown that the females of the species there (*H. stenolepsis)* may be mature at a length of 60—70 cm., and the males at a slightly smaller length (ca. 55 cm).

If it is not the inception of maturity which induces the migration, we may conclude, possibly, that these young halibut of about 45—60 cm. are led away from the district during their search for food. If this should be the case, it is not excluded that the migration takes place pelagically in the hunt for herring, sand-eels and the like; in this event then we should have for a number of halibut a biological period corresponding to the "Loddetorsk" stage. Lastly, we cannot wholly exclude the possibility that migrations like those here described may be peculiar to the Faroe area, which lies like an island out in the ocean; there, possibly, the physical conditions do not suit some of the young halibut, which therefore tend to move away and spread generally along the submarine ridge between the British Isles and Iceland. Continued investigations may show which of these or other possibilities are the cause of the migrations now discovered.

I have previously had occasion to emphasize that the marking of sea fish has not been made use of in fisheries investigations to anything like the extent the method deserves. Once again, in publishing the

[4]) 28. Ann. Rep. Fishery Board for Scotland. 1911, p. 48.
[5]) Meddel. Komm. Havundersøgelser; Fiskeri V, 5. Copenhagen, 1917.

above observations, I should like to underline this suggestion and to indicate, in this special case, that the enormous intensity of the halibut fishery presents favourable opportunities in this respect, since a relatively small number of marking experiments, for example in the North Sea, in the Skagerak, South Norway etc., would stand a good chance of yielding valuable results regarding the biology of this important food fish.

In spite of the importance of this species in the fisheries, it is a fact that extremely little is known of its life history; this is obvious, for example, from the experiment described above and from the experiences which have been made known in recent years regarding the spawning conditions in North Norway.

It is evident *inter alia* from the results of this small experiment that the stock of halibut at the Faroes is not a selfcontained stock, and that, consequently, isolated efforts at protection within this small area would not be of any great value, unless the fish was also protected in neighbouring areas. And protection, indeed a considerable degree of protection, is absolutely necessary if we wish to preserve this valuable species for the market.

Reviews.

Deutsche Seewarte. "Bericht über die erste Teilfahrt der Deutschen Nordatlantischen Expedition des Forschungs- und Vermessungsschiffes 'Meteor'. Februar bis Mai, 1937." Ann. d. Hydr. usw., LXV. Jahrg., Beih. z. H. IX, 29 S., 13 Abb., 1 Taf. Berlin, 1937.

As a result of co-operation between the German navy and the Forschungsgemeinschaft the "Meteor" is to supplement her 1925—27 survey of the South Atlantic Ocean and her recent work in Iceland—Greenland waters by an investigation of the greater part of the North Atlantic Ocean, from 15°N. to the Faroe Islands—Iceland Ridge, between the eastern seaboard and 60°W. The whole programme is not to be completed during one long commission, but by a number of shorter voyages lasting four to five months. The main observations to be made are physico-chemical and meteorological, and the work is to be directed by Professor D e f a n t.

The first voyage, partly a trial cruise, was made to the region between 10°N. and 28°N. and the African coast and 28°W.; the ship left Wilhelmshaven on February 4th, 1937, and returned on May 13th. Stations were worked along six east-to-west lines; the first observations were made in shallow water, the next two series in depths of 500 and 1,500 metres on the continental slope, and the offshore ones at about 60-mile intervals. Altogether about 70 stations were worked, about half of them falling between the African coast and the Cape Verde and Canary Islands. At each of the shallow stations continuous hourly observations were made over periods of 57 to 60 hours, and at one station, between the Cape Verde Islands, the vessel was anchored for two days in a depth of 2,140 metres for current measurements.

Only a preliminary account of the results is given. The region examined is one marked by coastal upwelling and the inshore water is sometimes 5° or 6°C. colder than the surface water in the open sea. A first examination shows, however, that only the upper 200 or 300 metres are affected. The continuous observations on the shelf reveal continual short-period changes, and a variation in the strength of the wind at the surface produces an almost immediate response in the thermocline at a depth of 25 to 50 metres. It was found that internal waves, breaking into eddies, could sometimes produce an unstable water column.

The current measurements at the deep anchor-station were made with the Böhnecke current-meter which makes no use of electric current but stamps figures giving direction and revolutions on a strip of tin foil carried by a drum driven by clockwork. The measurements were made to a depth of 800 metres; shallow measurements were made using bifilar suspension,

and those out of magnetic range of the ship with unifilar suspension. Several improvements in the method of working resulted from the long trial of the instrument. The chemical and physical observations included measurements of phosphate, silicate, nitrite, and transparency. Near the edge of the shelf, a region with a nitrite content as high as 30 mg.N/m³. at 50 metres was found to coincide with the occurrence of a rich zooplankton population, but farther south in a region of rich phytoplankton the nitrite values were not more than 4 to 6 mg.N/m³.

Below the thermocline there is a marked oxygen minimum which Dr. Wattenberg attributes to high consumption by sinking plankton remains, and some 200 and 400 metres below this a phosphate maximum and a weak intermediate silicate maximum. The differences of level are believed to be due to the different regeneration velocities of carbon dioxide, phosphate, and silica. The greatest silicate content occurs at a depth of 4,000 to 5,000 metres. It is emphasized that care must be taken in using a stratum of minimum oxygen content as an indicator of a horizontal current boundary, because it is felt that such a minimum could develop in a water mass with uniform movement at all depths. The phosphate and silicate curves show a small decrease in the neighbourhood of the bottom and the reasonable suggestion is made that this is due to combination, by adsorption or chemical reaction, with the bottom sediment.

G. E. R. D.

G. Wüst. "Bodentemperatur und Bodenstrom in der Pazifischen Tiefsee." Veröff. Inst. f. Meereskunde, N.F., Reihe A, H. 35, 56 S., 19 Abb., 3 Taf. Berlin, 1937.

The paper is an account of Professor Wüst's new examination of the Pacific Ocean bottom currents. Looking into all available records he has obtained some 1,500 temperature measurements, 1,100 being made with maximum and minimum thermometers. In order to check this mass of data he divides the ocean into 13 natural regions and compares each observation with all others of similar situation and depth. Of the 1,500 measurements, only 122 had to be regarded as quite untrustworthy.

In plotting the horizontal distribution of temperature the data are sorted into 5-degree squares; single observations were found not to differ by more than 0·1°C. from the mean values, and where the differences between neighbouring squares are greater than this they can be regarded as significant. It was, however, found necessary to reduce the observations made with maximum and minimum thermometers by 0·15°C. in order to bring them into line with modern measurements. The final chart of potential temperature at depths greater than 4,000 metres is attractively produced in colour.

Owing to the absence of a warm highly saline deep-current, the changes of temperature from south to north are very small. The Antarctic bottom current enters the West Pacific basin with a potential temperature nearly 1°C. higher than the water at the southern end of the Argentine basin in the Atlantic Ocean, but both oceans have the same bottom temperature by the time the currents reach 3°N.

There is a sub-Arctic bottom current in the North Pacific; it is small compared with the Antarctic current but much more powerful than the rudimentary Arctic bottom current in the Atlantic. It is formed in the Sea of Okhotsk, and it spreads over the Kurile Islands ridge. Although the Pacific Ocean is the farthest removed from the source of the cold Antarctic bottom water in the Weddell Sea there is a more extensive polar influence

in its bottom layers than in the Atlantic and Indian Oceans. In the North Pacific the bottom temperatures are lower than those of the North Atlantic. The main cause of the differences is the absence of a current like the North Atlantic deep-current.

The potential bottom temperature ranges from —0·1°C. near the Antarctic continent to 1·2°C. in a wide belt from south-west to north-east across the North Pacific. In isolated basins along the American and Australasian coasts it rises to 1·7°C., and in the Malay Archipelago to 2·7°C. and 3·3°C. In the Sulu basin between the Philippine Islands and Borneo there is a bottom temperature — in more than 4,000 metres — of 9·85°C.

Mention must be made of the complete historical summary, the critical examination of the measurements made by each exploring vessel, the new light thrown by temperature measurements on problems relating to bottom topography, and the general agreement between the spread of Antarctic bottom water and the distribution of sediments poor in calcium.

The careful examination of the temperature distribution in the Philippine basin shows that there is no definite evidence of heat conducted through the earth's crust. The "Snellius" observations (to 10,035 metres) show a small decrease of potential temperature near the bottom, and the "Planet" observations on either side of the deepest point show that there is a weak inflow of colder water from the oceanic side of the basin. ("wärmer" on p. 31 is apparently a misprint).

There are still localities with very few observations, and although it seems impossible that the chart should be seriously modified in the future, Professor W ü s t marks certain features as hypothetical. Emphasizing the shortage of modern observations he blames the echo-sounding machines. In this ocean, particularly, bottom temperatures will prove very helpful in the interpretation of lines of soundings, and no bathymetric chart should be produced without full consideration being given to them.

G. E. R. D.

R. Becker. "Über den jährlichen Temperaturgang auf dem Atlantischen Ozean." Ann. d. Hydr. usw., LXIV. Jahrg., H. V, S. 198—203, 2 Taf. Berlin, 1936.

On the basis of the temperature values published in the atlases of the Atlantic Ocean by the Dutch Meteorological Office (K.N.M.I., No. 110, 1918—1931) the writer has tried to give a clearer representation of the temperature variations from month to month for certain routes, one from New York to Capetown, a second from the English Channel to South America, a third between Scilly and New York. In order to eliminate uncertainties caused by the unequal number of observations available for neighbouring squares, isotherms were drawn, in addition to those for every 5°C. in the maps, for every single degree, and these were smoothed, as far as could be done without eliminating important features. The results were compared with those obtained in the same manner for the surface temperature, the differences plotted in diagrams, and on the supposition that these differences ought to show no sudden anomalies, corrections were applied to the air temperature, which surpassed 0·5 only in the north-western region.

It does not appear that the author consulted v a n R i e l's important paper on the surface temperature in the north-western Atlantic (K.N.M.I. No. 102/35, 1933) which gives 1° isotherms for the region just north of New York and for the whole of the western part of the route from Scilly to New York. The reviewer has compared the writer's figures for the surface

temperature with van Riel's values, and finds differences as high as 2°C. in some cases.

The results are given in tables, in the form of isopleths for the three routes, and in circular diagrams (polar co-ordinates) for the doldrums, the NE.- and SE.-trade regions and the point 42°N., 60°W. on the route Scilly — New York. In these diagrams the difference in temperature between air and water is indicated by shading, giving a very clear representation.

The thermal equator is placed at about 5°N.; the writer ascribes to this the fact that the temperatures in the South Atlantic are lower than in the North, but the influence of the Gulf Stream might also have been mentioned. Only the region between 4° and 9°N. shows double maxima and minima. The yearly range increases from only 0·7 at 5°N. to 10·6 in the north and 5·4 in the south. The isopleths show very clearly the special influence of the Gulf Stream by a large bend of the isopleths for 20—26° in the northern part. Also the circular diagrams show this important influence in indicating differences between air and water up to 4°C. in February; they also show clearly the lag with which the water temperature follows the air temperature.

From these diagrams and from the tables it appears that in general the water is colder when the air temperature rises, and conversely, so that this difference counteracts the annual variation. Hence it is evident that the water temperature (*in situ*) cannot be the cause of changes in air temperature. This conclusion holds good even if one assumes that air temperatures are as a rule read too high on board ships.

Further details may be found by consulting the paper, which certainly presents known facts in a new light.

van E.

G. Schott. "Die Aufteilung der drei Ozeane in natürliche Regionen." Petermann's Mitt. 82. Jahrg., H. 6, S. 165—170, 1 Taf.; H. 7/8, S. 218—222. Gotha, 1936.

Within climatology efforts have been made to establish definitions of climatological regions and to divide the earth's surface into areas of similar climatological characteristics. When such divisions are undertaken, the oceans have in some cases received the same attention as the continents, but Schott points out that the large amount of new data from the oceans makes a revision of earlier classifications desirable and that the principles of such classifications should themselves be revised. When defining the natural regions of the oceans, Schott attempts to put equal emphasis on the characteristic meteorological conditions and the oceanographic features of an area. This procedure, however, cannot always be followed, and in some instances the greater weight must be given to the meteorological conditions, while in other instances it must be given to the characteristics of the ocean's surface. It can, therefore, not be avoided that the subjective view of the author enters, but from the point of view of maritime meteorology and physical oceanography it appears that Schott has accomplished his difficult task in a very successful manner. The principles which Schott has employed appear to be sound, and few who know the oceans will deny that such characteristic differences exist and that the term "natural regions" can be introduced when dealing with the ocean's surface.

It is not possible to discuss Schott's contribution without mentioning Wüst's paper, "Die Gliederung des Weltmeeres" (*Petermann's Mitteilungen*, 82. Jahrgang 1936, 2. Heft, pp. 33—38), especially since Schott states that one may have to choose between the principles introduced by Wüst

and the ideas employed by himself. In the opinion of the reviewer there is, however, no need for making such a choice, since W ü s t bases his classification principally on the topography of the ocean bottom and advocates a systematic nomenclature for the ocean basins, whereas S c h o t t is concerned with the classification of surface areas. When dealing with the land one can describe the topography of certain areas and introduce geographical names for the outstanding features or one can describe the climatological regions of the same area. The regions of similar morphological characteristics need not coincide with the climatological regions, and the two classifications serve different purposes. Similarly, there need be no conflict between a classification based on the characteristics of the ocean basins and a classification of surface areas based on climatological and other features.

H. U. S.

R. B. Montgomery. "Fluctuations in Monthly Sea Level on Eastern U.S. Coast as Related to Dynamics of Western North Atlantic Ocean." Journal of Marine Research, Vol. I, No. 2, pp. 165—185. New Haven, Conn., 1938.

In der Arbeit werden die Ursachen der Schwankungen des monatlichen Mittelwassers an der Ostküste der U.S.A. untersucht. Ausserdem wird erwogen, wieweit Pegelbeobachtungen einen Einblick in die Dynamik der Gradientströmungen im Ozean erlauben.

Aus den Dichtewerten von "Atlantis"-Stationen aus verschiedenen Jahreszeiten werden mit den gleichen Methoden, wie die Topographie der Meeresoberfläche berechnet wurde (G. D i e t r i c h, "Die Lage der Meeresoberfläche im Druckfeld von Ozean und Atmosphäre .... "Veröff. Inst. f. Meereskunde, H. 33, Berlin, 1937), die Schwankungen der Oberfläche 1931/32 vor der Chesapeake-Bucht bestimmt. Sie zeigen eine gute Übereinstimmung mit den monatlichen Mittelwasserwerten der Pegelstationen von Miami und Charleston nach Eliminierung der Einwirkung des Luftdruckganges. Aus der Diskussion der möglichen Ursachen ergibt sich, dass der Gang der monatlichen Mittelwasserwerte von Miami in erster Linie durch die Dynamik des Floridastromes bedingt ist, während in Charleston bei einem breiten vorgelagerten Schelfstreifen noch lokaler Windstau hinzutritt.

M o n t g o m e r y greift meinen Schluss auf, dass Pegelregistrierungen von beiden Flanken eines Gradientstromes Einblick in die Stromschwankungen ermöglichen. Der Floridastrom ist für das Studium dieser Zusammenhänge besonders geeignet. Allerdings lagen bisher nur die Pegelregistrierungen von Key West und Miami vor, es fehlten Beobachtungen von der Gegenküste. Dem ist jetzt zum Teil abgeholfen, indem das Woods Hole Oceanographic Institution zusammen mit dem U.S. Coast and Geodetic Survey seit dem 1. März 1938 einen festen Pegel auf Cat Cay (Bimini-Inseln) in Betrieb haben. Man kann aus diesen Registrierungen beiderseits des Floridastromes in Miami und Cat Cay nicht nur einen Einblick in die langperiodischen Schwankungen im Floridastrom erwarten, sondern zugleich eine Vorstellung von den kurzen Strompulsationen gewinnen, über die wir heute so gut wie völlig im Dunkeln sind. Eine Lösung dieser Frage wäre nicht nur von speziellem wissenschaftlichen Interesse, sie gäbe zugleich eine vertiefte Kenntnis von der Dynamik des Golfstromes, die in mannigfacher Beziehung einen grossen praktischen Wert darstellen würde.

Im Schlussabschnitt wertet M o n t g o m e r y die Ergebnisse des Feinnivellements aus, indem er aus dem Abfall der Mittelwasserfläche von Cedar Keys bis St. Augustine um 19 cm. die mittlere Oberflächenströmung im

Floridastrome nach dem Torricellischen Theorem berechnet. Dabei wird aber die ablenkende Kraft der Erdrotation vernachlässigt. Der Widerspruch in diesem Ergebnis wird an der atlantischen Küste von U.S.A. besonders deutlich, denn aus dem Anstieg der Mittelwasserfläche nördlich von St. Augustine um 30 cm. bis Atlantic City nach dem Feinnivellement von 1929 (H. S. Rappleye, "The 1929 adjustment of the level net." *The Military Engineer*, Vol. XXIV, No. 138, 1932) wäre ein Gradientstrom gerade entgegengesetzt zum Golfstrom zu erwarten. Vielmehr scheint der Verlauf der Mittelwasserfläche längs eines Gradientstromes durch die Energiebilanz bestimmt zu sein. Ein Überwiegen der Zufuhr an Bewegungsenergie muss sich in einem Absinken, ein Überwiegen des Entzuges im Anstiege der Mittelwasserfläche äussern (siehe G. Dietrich, 1937).

Es kann nur begrüsst werden, wenn R. B. Montgomery die Errichtung einer dauernden Pegelstation in Habana fordert und den Anschluss von Miami und Key West an das vereinsstaatliche Netz der Feinnivellements vorschlägt. Beide Massnahmen sind notwendige Voraussetzungen zur Erforschung der Schwankungen in der Hauptwurzel des Golfstromes nach diesen neuen verheissungsvollen Methoden.

G. Dietrich.

A. E. Parr. "Further Observations on the Hydrography of the Eastern Caribbean and Adjacent Atlantic Waters." Bull. Bingham Oceanogr. Collect., Vol. VI, Art. 4, pp. 1—29, 23 figs. New Haven, Conn., 1938.

Diese Veröffentlichung legt eine kurze Darstellung des Materials der "Atlantis"-Fahrt im Januar 1937 vor. Vier hydrographische Nordsüd-Profile mit insgesamt 73 Stationen wurden durchgeführt, von denen zwei im östlichen Karibischen Meer liegen, nahezu in Deckung mit zwei Profilen der "Atlantis" aus dem März 1933, eines im Zuge der Kleinen Antillen, das alle wichtigen Durchlässe erfasst, und eines östlich der Inselkette im offenen Atlantischen Ozean. Damit ist die ozeanographische Erforschung des amerikanischen Mittelmeeres zu einem ersten Abschluss geführt. Unter einheitlichen Gesichtspunkten ist seit dem Frühjahr 1932 in grosszügiger Form nicht nur der gesamte Meeresraum von einem engen Stationsnetz überzogen worden, es wurden ausserdem alle wichtigen Durchlässe und deren Vorfeld im offenen Atlantischen Ozean untersucht.

Die vorliegende Arbeit will keine umfassende Auswertung des neuen "Atlantis"-Materials sein. Sie beschränkt sich auf die Diskussion zweier Probleme, erstens auf die Unterschiede in der Salzgehaltsverteilung zwischen den Beobachtungen aus dem Frühjahr 1933 und denen aus dem Januar 1937, zweitens auf die Beziehung zwischen vertikaler Stabilität und seitlicher Vermischung.

Zur ersten Frage stellt A. E. Parr die Salzgehaltskarten der Oberfläche und in 25 m. Tiefe aus den beiden Jahren gegenüber. Mit der Begründung, dass der höhere Salzgehalt im März 1933 sich aus Norden und Nordosten aus der Sargassosee ableite gegenüber dem niedrigeren Salzgehalt im Januar 1937, der aus Südosten aus dem äquatorialen Atlantischen Ozean herbeigeführt werde, findet diese Frage eine Beantwortung. Die Unterschiede in der Beobachtungszeit bleiben dabei unberücksichtigt.

Ein Vergleich beider Karten zeigt, dass die grossen Züge der Salzgehaltsverteilung im östlichen Karibischen Meer erhalten bleiben: ein verhältnismässig salzarmer Streifen zwischen salzreicherem Wasser im Süden im Gebiet der Leewärts-Inseln und im Norden im Gebiet der nördlichen Kleinen Antillen. Nur ist der Salzgehalt im Gesamtgebiet im Januar 1937 bedeutend

niedriger als im März 1933 (etwa 0·5 $^{0}/_{00}$). Eine meridionale Komponente bevorzugter Zufuhr tritt demnach kaum im Oberflächensalzgehalt in Erscheinung. Die Ursachen der Unterschiede scheinen vielmehr durch den jahreszeitlichen Gang des Oberflächensalzgehaltes im Ursprungsgebiet des östlichen Karibischen Wassers, im äquatorialen Atlantischen Ozean, bedingt zu sein. Nach der neuesten zusammenfassenden Bearbeitung des Oberflächensalzgehaltes (G. Böhnecke, "Atlas zu: Temperatur, Salzgehalt und Dichte an der Oberfläche des Atlantischen Ozeans." Wiss. Ergebn. Deutsch. Atl. Exp. "Meteor", Bd. V, Berlin 1936) weist die Äquatorialzone einen deutlichen jahreszeitlichen Gang im Oberflächensalzgehalt auf, indem im April die höchsten, im September/Oktober die niedrigsten Werte auftreten. Dieser Gang wird durch die Oberflächenströmungen dem Ostkaribischen Meere mitgeteilt, woraus sich der regional höhere Salzgehalt im März (1933) gegenüber dem im Januar (1937) zum Teil erklären liesse.

Bei der Diskussion der zweiten Frage weist A. E. Parr auf die starke Wirkung der seitlichen Vermischung in den Durchlässen zwischen den Kleinen Antillen hin, die bereits im östlichen Karibischen Meer eine auffallende Gleichförmigkeit im hydrographischen Aufbau entstehen lässt gegenüber den Verhältnissen östlich der Kleinen Antillen.

In seiner Untersuchungsmethode der Beziehung zwischen vertikaler Stabilität und horizontaler Vermischung ist A. E. Parr eine Schwierigkeit entgegengetreten. Das Salzgehaltsmaximum und -minimum, an denen die Beziehung von ihm untersucht wurde (A. E. Parr, Journ. du Cons., Vol. XI, No. 3, 1936), werden gerade als die ungeeignetsten Schichten für die Darstellung der Beziehung erkannt; denn in diesen Schichten tritt bei dem geringen vertikalen Gradienten des Salzgehaltes die Wirkung einer vertikalen Vermischung am wenigsten in Erscheinung. Die seitliche Vermischung erhält damit ein scheinbar zu grosses Gewicht. Aus diesen Überlegungen heraus schränkt A. E. Parr früher gezogene Schlüsse ein und erwartet aus Untersuchungen in der Atmosphäre und aus experimentellen hydrodynamischen Versuchen, die zur Zeit laufen, eine Klärung der Beziehung zwischen vertikaler Stabilität und seitlicher Vermischung. Jeder Vorstoss in dieser Richtung kann, wie die vorliegende Arbeit, nur begrüsst werden, da sie zur Vertiefung unserer Bewegungsvorstellungen in Ozean und Atmosphäre geeignet erscheinen.

G. Dietrich.

H. H. Darby, E. R. F. Johnson and G. W. Barnes. "Studies on the Absorption and Scattering of Solar Radiation in the Sea." Pap. Tortugas Lab., Carnegie Inst. Washington, Vol. XXXI, pp. 193—205, 5 figs., 1 pl. Washington, D.C., 1937.

This paper presents and compares results obtained in the sea and in the laboratory on absorption and scattering of solar radiation.

Each of these studies was made by means of observations with a quartz spectrograph and with two Weston illumination meters. The transmissive exponents were measured by means of the quartz spectrograph which was mounted in an aluminium housing set up and aligned by a diver on the ocean bottom in shallow water. The experiments consisted of making exposures on photographic plates with the spectrograph placed on the ocean floor and comparing the results of these exposures with others made on shipboard either before or after the apparatus had been submerged. The density of the plates was measured by a recording densitometer of conventional design.

The calibration exposures were made using a 64 c.p. automobile headlight

as a source. In comparing the density of plates exposed in water, it would seem that some uncertainties were introduced which might materially affect the values of the transmissive exponents. Since some time must elapse in moving the boat and the apparatus to various locations in order to obtain different depths of water, there was undoubtedly considerable change in the intensity and character of the radiation incident upon the surface of the water. Also there might have been appreciable change in the nature of the water column through which the light travelled.

The results on the penetration of the ultra-violet show marked deviations from the data of Sawyer (Contrib. Canad. Biol. and Fish., 7, 75, 1931) and from the data of Hulburt (Journ. Opt. Soc. Amer. 22, 408, 1932). Transmissive exponents between 3240Å and 4500Å for a layer of water 1·87 metres thick are given. The authors' value is approximately one-fifth that obtained by Sawyer at 3240Å and approximately one-fourth that obtained by Hulburt at the same wave-length. Between 4000Å and 4500Å the results of these authors are in agreement with those of Sawyer and are in approximate agreement with the results of Hulburt in this wave-length range.

The authors' method of computing transmissive exponents does not reveal, without further calculation, the absorption characteristics of the water studied. Column 2 in Table 2 of the paper shows relative intensities of light from 4500Å to 3240Å. The figures given are determined from the densities of the plates when exposed at a depth of 0·33 metres. A value of unity is assigned to wave-length 4500Å and relative intensities for 4500Å at 2·2 metres were computed using, first, Hulburt's value for the absorption coefficient for light of this wave-length, and again, by using Sawyer's coefficient for the same wave-length. From these calculations result the first figure in Column 3 and in Column 4. All other values of relative intensities at 2·2 metres were then obtained from the densitometer analyses of the photographic plates. In making the computations in this manner, no account is taken of the different conditions of the ocean water used by the individual experimenters. Sawyer made his measurements soon after taking the water from the source. He used two samples and makes no reference to filtering. One sample gave a value of $k = 0{\cdot}169$ at 4500Å, and the other a value of $k = 1{\cdot}22$ at 4500Å. Since Sawyer took these two samples at locations where the water had different characteristics, the necessity of describing the samples is obvious. Hulburt let his samples stand in the laboratory for several months to insure settling of foreign matter and then decanted water for measurement. The paper shows relative intensities varying from 1·00 to 0·11 as the wave-length changes from 4500Å to 3240Å at a depth of 0·33 metres. Since relative intensities at the same wave-lengths were measured at 2·2 metres, it is not apparent why the authors failed to compute values of transmissive exponents for a layer 1·87 metres thick. Their results given in Columns 5 and 6 show that their exponents are correct if Hulburt's and Sawyer's values for 4500Å are correct.

On page 203 the authors state, "The surface intensity differed by three per cent, as measured by a deck photometer". On page 194 the spectral sensitivity curve of the cell used in the deck photometer shows that the response of the cell rapidly approaches zero for wave-lengths approaching 3240Å. The maximum response of the cell is at about 5800Å. It is possible that a total change of three per cent. in the deck photometer might mean a small change in the wave-length region under consideration, or it might mean a very large change in this region. If a deck photometer is to be used

as an indication of variations in incident sunlight during a series of measurements, its response should be limited to those wave-lengths being measured rather than the integrated effect of all sunlight.

The relatively low transmissive exponents in the ultra-violet region obtained by the authors in the southern waters are of considerable importance. The spectrograms, reproduced in the paper, show the presence of light of 3000Å wave-length at a depth of 3·42 metres. The exposures were made between 10·30 a.m. and 2·40 p.m. Scattering curves are given which show selective scattering between 3300Å and 5600Å for a depth of 2·2 metres. The scattering is greater for the shorter wave-lengths.

The paper concludes with an interesting discussion of the biological importance of the low values of the ultra-violet transmissive exponents.

C. L. U.

H. Wattenberg. "Kalkauflösung und Wasserbewegung am Meeresboden." Ann. d. Hydr. usw., LXIII. Jahrg., H. X, S. 387—391. Berlin, 1935.

H. Wattenberg und E. Timmermann. "Über die Sättigung des Seewassers an Ca_3CO_3 und die anorganogene Bildung von Kalksedimenten." Ann. d. Hydr. usw., LXIV. Jahrg., H. I, S. 23—31., Abb. 1—6, 8 Taf. Berlin, 1936.

In the first of the above papers, Wattenberg shows how chemical investigations in the sea may prove useful as a source of information regarding large-scale water-movements; in particular, how alkalinity measurements may be utilized to furnish at least an approximate estimate of the rate of oceanic bottom currents. The region chosen by way of illustration is the Brazilian Basin, where the bottom waters are those of the Antarctic bottom current.

From values of specific alkalinity (A/Cl) at the lowest depths at four "Meteor" stations in the northern part of the Brazilian Basin about latitude 5°S., the average distribution over the sea floor in this region is derived by graphical means. Thus it is found that specific alkalinity begins to increase at about 1100 metres from the bottom, from a normal value of 0·1225 (obtained separately from a number of independent determinations) to 0·1280 at 50 metres from the bottom. Any increase below 50 metres was, by experiment, shown to be improbable. The A/Cl gradient thus derived corresponds to a decrease in lime-content (dK/dz) from the bottom upwards, of $5{\cdot}0 \times 10^{-11}$ g./cm., and this quantity, multiplied by an exchange-coefficient A, gives the amount of $CaCO_3$ dissolved per second from a sq. cm. of the sea floor.

For a Red Clay poor in lime, such as is found within the range of Antarctic bottom water, and by a process of assumption and reasoning based on various estimates of the rate of dissolution of $CaCO_3$ from different marine sediments, A is reckoned at about 4 $cm.^{-1}$ $g.\ sec.^{-1}$, corresponding to a dissolution of $1{\cdot}9 \times 10^{-10}$ g. $CaCO_3$ per second per sq. cm. of sea bottom.

It is then argued that, in view of its origin, the bottom water at the South Sandwich Ridge in latitude 50°S. most probably has a normal specific alkalinity of 0·1225. In Latitude 5°S. the mean specific alkalinity of the 1100-metre bottom layer is 0·1255, representing, in the water column of 1 sq. cm. cross-section, an increase of $6{\cdot}4 \times 10^{-10}$ g. $CaCO_3$ per cm. of the distance (ca. 5000 km.) from 50°S. to 5°S. Assuming the bottom current to be moving northward with a velocity v the rate of increase is therefore $v \times 6{\cdot}4 \times 10^{-10}$ g./sec. cm. which may be equated to the above-calculated rate of dissolution of $CaCO_3$ from the sea floor.

i.e. $v \times 6{\cdot}4 \times 10^{-10}$ (g./sec. cm.) $= 1{\cdot}9 \times 10^{-10}$ (g./sec.)

whence $v = 0{\cdot}3$ cm./sec.

As pointed out by the author, while this value, on account of the uncertainty attending the calculation at several points, may not be independently and finally acceptable, it is in such close agreement with values derived in other ways — from Defant's $\frac{\text{Exchange-Coefficient}}{\text{Current Velocity}}$ ratio for instance, by substitution of the above exchange-coefficient of 4 — that a mean velocity of between about 0·5 and 1·0 cm./sec. for the Antarctic bottom current may be taken as at least highly probable.

The second paper raises anew the question of whether some part — that part at least which contains no trace of organic matter — of the calcareous sediments of the relatively shallow "Schelfmeeren", especially in the tropics, may not be the result of spontaneous precipitation of $CaCO_3$ from lime-supersaturated waters. The question, as the authors remark, has as often been answered in the negative as in the affirmative, although for some time following the work of G. H. Drew, the origin of the amorphous carbonate in these deposits was attributed to the action of fixed bacteria. This, however, in view of later work, cannot be accepted as sufficient explanation. In short, experimental evidence bearing on the matter has so far been inadequate.

As a practical proposition the question falls into two parts; (i) Do conditions exist anywhere in the sea which are favourable towards the inorganic separation of $CaCO_3$? and (ii) If and where such conditions occur, does precipitation actually take place?

The first question is to be answered by accurate determinations of the solubility of $CaCO_3$ in sea water of varying temperature, salinity, CO_2-pressure or pH. The authors' experiments, fully described and the results graphically illustrated, would appear to meet the demands of accuracy. In this respect, recent experiments by Revelle and Fleming are criticized and experimentally shown to be at fault in that equilibrium was not established in the treatment of sea water with $CaCO_3$, whereby the conclusion was reached that surface waters, even in tropical regions, may only approach saturation. Wattenberg and Timmermann find that surface waters, in equilibrium with the atmosphere as regards CO_2-tension, are at all temperatures supersaturated, especially in tropical regions where supersaturation may exceed 300 %. Subsaturation occurs only when, by decomposition of organic matter, CO_2-tension in the water is raised above that of the atmosphere. Salinity on account of its small variation has little effect on solubility, CO_2-tension the greatest influence, followed by temperature. The conditions in CO_2-tension and pH for 100 % saturation at 0°, 10°, 20° and 30°C. are given in a useful little table on page 28.

In general, then, the first essential for inorganic precipitation of carbonate would appear to exist practically everywhere in the surface waters of the sea, and where there is contact of these waters with solid $CaCO_3$, as in the lagoons of coral reefs and in shallow seas where agitation is sufficient to stir up the bottom to some extent, precipitation of $CaCO_3$ from the supersaturated waters must inevitably occur. It does not of course follow that the total excess carbonate will come down. The extent of precipitation probably depends upon several factors, the chief being the abundance in distribution of lime-particles which act as germs of crystallization.

On the rate of precipitation, the authors conducted experiments whose results, while they can scarcely be applied quantitatively to natural conditions, enable an upper limit to the probable rate of deposition of amorphous sediment in tropical regions to be calculated. This seems to be in the neighbourhood of somewhat less than 1 mm. (thickness) in a year.

The probability of precipitation of carbonate from the supersaturated waters of temperate seas, like the North Sea for instance, was also put to the test of experiment, the result being to demonstrate the improbability of such precipitation on account of the ineffectiveness of even fine sand as germs of crystallization.

Finally the origin and maintenance of supersaturation in the surface layer is briefly discussed.

Both papers are a useful contribution to the comprehensive and highly complex problem of the occurrence of lime in the sea and on the sea floor.

J. B. T.

K. Stoll. "Beitrag zur Analyse der Stickstoffverbindungen im Meerwasser." Zeitschr. f. anal. Chem., Bd. 109, H. 1/2, S. 5—15, 4 Abb. München, 1937.

The optimum composition of the Nessler reagent for determination of ammonia is shown to be: mercuric iodide (115 g.), potassium iodide (87 g.), double distilled water (500 c.c.) and 6N caustic soda solution (500 c.c.). In agreement with Wirth and Robinson, Stoll finds that the reagent cannot be used below about 15 mg. NH_3—N/m^3. In the method of Buch and Witting, the long standing-time, required for the precipitated calcium and magnesium to settle, may be avoided by filtering through a membrane- or cella-filter.

The phospho-molybdo-tungstic complex acid (Folin and Ciocalteu) is suggested for the determination of amino-acids in sea water. Interfering substances are noted. The reagent is stated to be able to determine a minimum concentration of 100 mg. amino-N/m^3. in a 3 cm. column. Comparison of the extinction of light shown in Stoll's Fig. 3 with the extinction coefficients in the standard method of determining phosphate suggests that 2 mg. of amino-nitrogen gives much the same depth of colour as 1 mg. phosphate-phosphorus. If this is indeed so and colour proportionality holds below 100 mg.N/m.^{3}, the method ought to be applicable to the amounts that probably occur in the sea, provided that longer columns be used.

In the determination of nitrate by reduced strychnine, iron in excess of 200 mg. Fe/m.^{3} or quadrivalent manganese in excess of 60 mg. Mn/m.^{3} cannot be neglected; 535 mg. Fe or 355 mg. Mn develops the same amount of colour as 25 mg. nitrate-N.

L. H. N. C.

C. W. Correns, V. Leinz und O. E. Radczewski. "Die Sedimente des äquatorialen Atlantischen Ozeans. 2. Lief. C. Zusammenstellung der Untersuchungsergebnisse nach Stationen geordnet. D. Auswertung der Ergebnisse." Wiss. Ergeb. deutsch. Atlant. Exped. a. d. Forsch.- und Vermessungsschiff "Meteor" 1925—1927. Bd. III, Teil III, S. 135—298, Abb. 58—107. Berlin u. Leipzig, 1937.

All workers on bottom deposits will welcome the publication of the "Meteor's" results by such an eminent authority as Prof. Carl W. Correns, of Rostock University. The samples investigated were collected in the equatorial regions of the Atlantic Ocean. Both core samples, obtained by a modified Ekman sampler and in length up to 95 cm., as well as grab samples have been studied. The first portion of the report is concerned with a summary of the results, arranged according to station number. In general

the upper, middle, and lower portions of each core were investigated, and in each portion $CaCO_3$, Fe_2O_3, MnO, TiO_2, P_2O_5 and the humus were estimated. Grain-size determinations were done, apart from two sieved fractions, by a modified Odén balance, and results were expressed in five fractions. Minerals were determined in the coarser grades by ordinary petrographical methods, and in the clay fraction ($< 1\mu$) by means of X-rays. In addition, percentages of foraminifera, diatoms, etc. are given.

The second part of the report is concerned with the interpretation of the results. The grain-size determinations and the geochemistry of the sediments are dealt with by Correns, whilst the minerals in the sediments from the Guinea Basin are described by Victor Leinz, and those from the Cape Verde region by O. E. Radczewski. The sediments have been divided, according to their grain-size distribution, into fifteen types, ranging from those which show a maximum of particles smaller than 1μ to those which have a maximum in the 100μ—1000μ grade. Drying a sediment increases the coarser grades at the expense of particles smaller than 1μ, but it is probable that with a different preliminary treatment more concordant results would have been obtained.

A detailed discussion is given of the lime content in sediments, and Correns proposes to redefine globigerina ooze as being a sediment in which the foraminiferal number exceeds 6000. An attempt is made to trace the connexion between the degree of saturation of sea water with $CaCO_3$ and the carbonate content of the sediment. It is pointed out, as is well known, that the solubility of $CaCO_3$ depends on pressure, temperature, and the amount of carbon dioxide in the water. The solubility of $CaCO_3$ is therefore not purely a question of depth, but also depends on the origin and previous history of the water. It is natural to expect agreement, only in those areas, where the contribution by non-calcareous components has been approximately the same. Comparing the degree of saturation of sea water at 4,000 metres with the amount of $CaCO_3$ in the sediment, Correns finds a general agreement, and he considers that the notable exceptions may be due to water samples not being taken sufficiently close to the bottom. An interesting map is given of the distribution of $CaCO_3$, and the sediments in the Romanche Gap (based on theoretical grounds) have according to the map a smaller carbonate content than those on the Mid-Atlantic Ridge, in spite of the fact that many sediments from this area have a higher carbonate content. A study has been made of the distribution of $CaCO_3$ in the deeper layers of the core samples. In general these show a reduction and it is suggested that a deterioration of climatic conditions would reduce the number of foraminifera and consequently the lime content of the sediments. W. Schott has deduced from the foraminiferal content that some of the cores have passed through a glacial and penetrated into an interglacial period.

The geochemistry of iron, titanium, manganese, and phosphorus is treated in considerable detail, and charts are given of their distribution. Low amounts of titanium, manganese, and iron occur in sediments collected in water shallower than 200 metres, whilst in sediments from greater depths a higher proportion of these elements is found. An interesting feature is the low humus content of the sediments, the highest values occurring in sediments collected at a depth of 2000—3000 metres. Complete chemical analyses are limited to sediments from six stations, and from this it is concluded that apart from $CaCO_3$ there is no fundamental chemical difference between a globigerina ooze and a red clay. Later on, in the report, arguments are advanced to show, in all probability, that red clay does not originate by the decomposition on the ocean floor of volcanic material.

In his description of the minerals from the Guinea Basin Victor Leinz, after describing both qualitatively and quantitatively the minerals from three sedimentary types, globigerina ooze, blue clay and littoral sediments, concludes that blue clay and globigerina ooze do not differ in their essential mineral components. Radczewski's contribution deals with the minerals from the Cape Verde region, and his description of desert dust in the sediments of this region is of interest. He is able to recognize desert quartz by its coating of red-brown Fe_2O_3, and by its presence, in portions of the cores corresponding to the last glacial and interglacial periods, he concludes that the African desert regions existed as such in the glacial times.

The material finer than 1μ has been examined by X-rays. Mehmel, who has been responsible for this portion of the work, has demonstrated the presence of calcite, quartz, mica, halloysite, (Al_2O_3 $2SiO_2$ $4H_2O$), kaolin (Al_2O_3 $2SiO_2$ $2H_2O$), montmorillonite (Al_2O_3 $4SiO_2$ nH_2O), and in smaller amounts felspar, augite, and aragonite. An interesting chart is given showing the distribution of montmorillonite, halloysite and kaolin. Finally a short description is given of a basalt obtained from the Mid-Atlantic Ridge; a more detailed account of this has been previously published in *Chemie der Erde* for 1930.

It can be said without hesitation that this report is the most up-to-date published account of oceanic sediments, and it therefore should be studied by all those who are interested in sediments. Its value would no doubt have been greater if closer attention had been given to other branches of oceanography, especially if the water in immediate contact with the sediments had been investigated, but this was impossible with the Sigsbee water bottle. Finally, it is unfortunate that the "Meteor" expedition has been unable to contribute appreciably to the solution of that puzzling tectonic feature — the Mid-Atlantic Ridge. It is now becoming evident to oceanographers that active cooperation is required between varying sciences in order to solve many of the more important oceanic problems. In the future bottom samples will have to be both more carefully collected, and studied in conjunction with relevant chemical determinations on the bottom water. Perhaps by this means, combined with detailed survey and geophysical work, many of the physical problems of the oceans will ultimately be solved.

John D. H. Wiseman.

R. Jurva. "Über die Eisverhältnisse des Baltischen Meeres an den Küsten Finnlands nebst einem Atlas." Havsforsk. Skr. No. 114, 248 S. 95 Abb. Atlas. Helsingfors, 1937.

For this survey, the Finnish waters were divided into 5 districts, viz., Bottenvigen, Kvarken, the Botten Sea, the Åland Sea, and the Finnish Bight. The oldest Finnish material of the ice conditions used in the paper dates from the beginning of the 19th century and part of it was collected by the author from Finnish and Swedish newspapers. There exist, however, occasional records from older times, the earliest from the year 1269, of people being able to travel by sleigh from Estonia to Sweden, presumably across the Finnish Bight and then *via* the Åland Sea to Sweden. From 1850 onwards yearly records about the ice along the coasts exist; from 1870 there are 34 stations of observations from which a fairly reliable picture of the ice conditions may be formed, and from 1877, when the winter communication between Sweden and the Åland Sea was started, a clearer idea of the ice conditions at sea was obtained. From the years 1898—1902 there are ice maps of the Finnish Bight and the northern Baltic, and later Professor

R. Witting issued his well-known maps for the following years. The paper then gives a survey of the further development of the ice observations and investigations on the subject.

In a later section the nature of the various sorts of ice and ice formations is described, and also the open channels along the coasts peculiar to the Finnish waters. In addition, an account is given of the results of a study of the normal course of an ice-winter, comprising three periods, the early winter, mid-winter, and spring, all of which have been studied in great detail, which fact renders the paper of especial scientific value. Various illuminating tables accompany this account, which does its author great credit.

The number of days with ice in a normal ice-winter affords a good guide as to the probable duration of ice conditions in the northern Baltic and at the same time forms a basis for judgement as to how far south into the Baltic proper ice can normally be expected to go.

The paper contains a list of publications dealing with the ice conditions etc. in Finnish and other waters. I would especially draw attention to the information about the different winters published by the Institute for the Exploration of the Sea and to the extensive hydrographical-biological investigations carried out by this Institute. In all, 80 publications are mentioned. Dr. Jurva's own is a work of 248 pages, a very extensive as well as a most painstaking work, of exceedingly great importance for the understanding of the ice formations, not only in the Botten Sea and the Finnish Bight. It may serve as a model for similar investigations in other waters even though the different stages in the very long ice-winter are peculiar to Finnish conditions.

The Institute for the Exploration of the Sea and Dr. Jurva are much to be congratulated on this meritorious and valuable work.

C. I. Speerschneider.

Fr. Gessner. "Hydrographie und Hydrobiologie der Brackwässer Rügens und des Darss." Kieler Meeresf., Bd. II, H. 1, S. 1—78, 1 Karte, 38 Abb., 2 Taf. Kiel, 1937.

Besides an introductory geological sketch of the region explored, this paper contains detailed descriptions of and a comparison between the various "Bodden" (fiords or lagoons), including the large Greifswalder Bodden, of a small but interesting part of the German Baltic coast, interesting because it is situated at the most southerly point of the line that divides the Baltic into a western, more or less marine, part and an eastern, purely brackish one. Rügen is an island familiar to travellers to Sweden, the Darss is a part of the shore west of it.

The waters of this district, being connected directly or indirectly with the sea, belong to the mesohaline type, but the salinity, ranging from ± 12·0—2·0 ‰, naturally diminishes from the outside towards the innermost, more or less landlocked lagoons.

The plankton of these waters is discussed in detail, both qualitatively and quantitatively, and a good deal of information is given as to its composition in connexion with the salinity of the various lagoons. It is worth noting that the Kleiner Jasmunder Bodden, the innermost and shallowest of the series on Rügen, (S between 2·3 and 2·4 ‰) is characterized by an enormous development of Cyanophyceae and Chlorophyceae belonging to the nannoplankton, so that in all seasons the water is like a thick green soup ("ein dicker grüner Brei"). Only a few pelagic Copepods are recorded: *Acartia longiremis* from the adjoining Baltic ("Arkona-Becken"), *Ac. bifilosa* from

the Hiddenseer, Greifswalder and Grosser Jasmunder Bodden, and *Eurytemora hirundoides* only from the Kleiner Jasmunder Bodden. It is rather curious that this species, which is very common in the open Baltic, was only met with in such an abnormal milieu (Table II, p. 74). *Acartia tonsa* is not mentioned, although it was present in the Polish coastal waters as early as 1925 (Rzóska, in: Arch. Hydrobiol. Ichthyolog. Suwalki, XI, 1938).

It is a pity that the records of the non-pelagic animals are very poor, because these characterize the different associations of brackish waters better than the floating ones. The statement (p. 51) that *Eriocheir sinensis* was introduced from Japan seems to be a *lapsus calami*.

H. C. R.

E. Wohlenberg. "Die Wattenmeer-Lebensgemeinschaften im Königshafen von Sylt." Helgoländer Wiss. Meeresunters. Bd. I, H. 1, S. 1—92, 67 Abb. Kiel, 1937.

According to the introduction the object, the ecological task, of this paper is to furnish a contribution to the explanation of the relationship between the fauna found in the Wattenmeer (shoal sea) and its natural environment.

The area which has been under investigation, the Königshafen, is a shallow-water inlet, situated off the northern end of Sylt, and joined to the main part of the Wattenmeer by a very narrow channel. So far as the analysis of conditions in this section of the shoal area is concerned, the paper contains an extremely valuable series of observations relating to a number of hydrographical factors. Simultaneous observations were made of the temperature, the salinity, the oxygen-saturation, the H_2S content, and the pH throughout complete tidal periods in various localities in the area.

On one point concerning the economy of the water the paper under review displays in a marked degree an absence of information: the data for the various sample lines do not show precisely the periods when the area was covered by water. This omission is all the more regrettable because that is a factor which constitutes one of the most characteristic features of shoals and its great significance has been demonstrated in many previous investigations[1]).

Investigations carried out over the shoal-bottom itself have dealt in detail with the size-conditions of the sand-granules and with the water-content, while similarly the water from the same shoal-bottom has been subjected to analysis in respect of salt, O_2, H_2S, and pH. On the basis of these investigations, Wohlenberg has presented various types of sediment which are characterized, not merely by the size-conditions of the sand-granules, but also by the other factors mentioned. Correctly or incorrectly, Wohlenberg thus uses the term sediment in a much wider sense than is usual in investigations of this nature, but he also attains thereby a much finer graduation-scale. According to Wohlenberg's interpretation, there exists in the Königshafen so characteristic a relationship between the sediment and the stock of fauna that a survey of the sediments of the Königshafen automatically defines the limits of the various stocks of fauna. It may at this juncture be remarked that it would have been far preferable if these quantitative investigations had been published in greater detail than is actually the case; this applies equally to comparisons with other localities, which would have been of great value in themselves. Wohlenberg's

[1]) A survey on flood-periods at Königshafen, however, has been recorded in 1927, by Nienburg, but these figures are not immediately applicable to the present work.

viewpoint on the significance of the size-conditions of the sand-granules is, however, not equally clear. In the summary on pages 85—87 special prominence is given to this factor in connexion with the saturation of the bottom; but elsewhere (e.g., p. 90) the author indicates that the air-content of the bottom, the water-content (over-saturation and under-saturation) the compactness and the embedment far exceed in importance the size-composition of the sand-granules as the "basic criterion". This latest deduction agrees to no small extent with what has already been ascertained from deeper waters in respect of the size of the granules so far as the animal forms dealt with here are concerned. But as to the occurrence of *Cardium* Wohlenberg is of the opinion (pages 42—43) that he finds a certain correlation to pure sand-bottom in preference to silt-mixture bottom and emphasizes this as a contrast to the findings of Hecht and Matern in the German, and of the reviewer in the Danish, Wattenmeer, although it is emphasized, so far as the Danish Wattenmeer is concerned, that within much wider limits *Cardium* is independent of the character of the bottom. The distribution of *Cardium* is on the contrary dependent upon the periods of tidal overflow, which Wohlenberg does not directly indicate. (Cf. Thamdrup: Medd. Komm. Danm. Fiskeri og Havunders. X, 2, pp. 49 & 109).

In this connexion it seems precarious to the reviewer that, in the analyses of the distribution-conditions of the species, the types of sediment are so strongly stressed, while the periods of tidal overflow, for example, are completely left out of account in the summary (pp. 85—87). It will in point of fact be quite easy to find a silt-shoal (Watte) which, in contrast with the investigations described in respect of the Königshafen, lies much deeper in the inter-tidal zone and, despite corresponding features so far as the conditions of granule-magnitude, water-content, etc., are concerned, will manifest the dominance of faunal elements totally different from those adduced by Wohlenberg. On a shoal which lies so deep a plankton-eater such as *Cardium* will, for example, be able to enjoy the most favourable conditions and those most conducive to its welfare (cf., for example, *op. cit.* Buhnenlinie pp. 88—90).

Regarded from an ecological standpoint it seems dangerous to collate certain faunal elements with certain external factors so long as it cannot be substantiated in what manner the individual species are dependent upon the factors in question. The reviewer will therefore in this connexion point out how desirable it is that in the future not merely shall an endeavour be made to furnish detailed analyses of the environment, but also, both in the laboratory and in the field, in no less a degree to make analyses of the species, by a study of the requirements and the adaptability of the individual species to the distinctive external environment. On this last point, unfortunately, we still know all too little.

As a more important contribution in this field in the paper under review there may be mentioned the studies of the relationship of *Arenicola* and *Nereis* to the drying-out of the upper surface of the shoal together with the embedment of dense layers of *Zostera* at the bottom.

In regard to ecological methods Wohlenberg's paper also throws light upon a factor which is all too often overlooked. Thus Wohlenberg, citing various admirable examples, particularly in respect of certain of the beetle (*Bledius*) communities, lays emphasis upon the fact that the ecologist must to a very great extent take into consideration the general development which a given locality has undergone. Single pictures give all too easily a false impression of equilibrium about which a biocoenosis oscillates or towards which it moves. Wohlenberg gives examples of

the magnitude and rapidity of the oscillation of which fauna in a shoal area is capable, partly from a shoal where the shifting of the fauna seems to be connected with the mortality of *Fucus* (p. 44), partly from a deep-lying sand-shoal, where the picture is changed by a heavy deposit of *Cardium* spat in 1934 (p. 39), a deposit which, however, on account of the exposed nature of the locality, must be regarded as having had a very short lived significance (cf. "patches" of certain bottom fauna in deeper water). However, Wohlenberg draws a comparison between the productivity in this locality and a shoal at Skallingen (*op. cit.*, pp. 88—90). The mortality of the 0-group in the Königshafen, after a lapse of four months, is given at 69 %; at Skallingen it was 91 %. While the spat at the first-named place was practically free of competition with adult *Cardium*, it must be remarked that at the latter place it had to compete with a stock of about one thousand adult *Cardium* to the square metre. Therein lie the causes of the difference in mortality, so that this circumstance can throw no light upon the productivity.

Even if the animal stock on the shoal may at times vary considerably, none the less it seems to display an amazing stability, which is disturbed only by the occurrence of catastrophes such as arctic winters, mortality of *Zostera*, etc. Further studies of the fluctuations of the shoal fauna will be of the greatest interest, not least in respect of the understanding of the corresponding conditions in deeper water.

On the whole it must be said that Dr. Wohlenberg's paper deals in a striking manner with the outstanding phenomena in the shoal waters (Wattenmeer), and there is no doubt that his vivid descriptions and the great wealth of illustrative material will contribute to strengthen interest in the investigation of the tidal shoals, which, by purposeful ecological studies, with equal regard to analyses of both environment and species on a quantitative basis, ought to be capable of being considered a kind of experimental field in modern marine work.

H. M. Thamdrup.

W. Garstang. "On the size-changes of diatoms and their oceanographic significance." Journ. Mar. Biol. Assoc., Vol. XXII, No. 1, pp. 83—96, 9 figs. Cambridge, 1937.

Wimpenny hat darauf aufmerksam gemacht, dass die zunehmende Verkleinerung planktonischer Diatomeen von Generation zu Generation bei den Teilungen und ihre Vergrösserung bei der Auxosporenbildung ein Mittel zur Beurteilung ozeanographischer Verhältnisse sein könne. Er deutet seine Befunde an *Rhizosolenia styliformis* aus der Annahme, dass Temperaturerhöhung des Wassers eine Auslese der grösseren Formen zur Folge hat. Garstang stimmt dem Grundgedanken Wimpennys zu. Er ist der Überzeugung, dass in der Tat die Regelmässigkeit des Lebenscyclus' der Diatomeen, seine lange Dauer von wenigstens zwei Jahren und die Kontraste, welche er einschliesst, ihn besonders für biometrische Untersuchungen mit ozeanographischen Zielen geeignet machen. Er deutet jedoch die Befunde anders als Wimpenny, nämlich aus der Mischung verschiedener Populationen. Zu drei empirischen Variationskurven über den Durchmesser der *Rhizosolenia*-Zellen südlich der Doggerbank im Oktober 1932 werden zwei theoretische Kurven, eine zweigipfelige und eine eingipfelige, entworfen, die zwei reinere Populationen darstellen sollen, und deren Kombination (als Ausdruck der angenommenen Mischung) in überzeugender Weise den empirischen Kurven entspricht. Das reichere, auch nördlichere Gebiete betreffende

Material von 1933 und 1934 gestattet ähnliche Deutungen, und zwar ist der entscheidende ozeanographische Faktor für die Verteilung und Mischung der Populationen augenscheinlich das stärkere oder schwächere Eindringen atlantischen Wassers von Norden in die Nordsee und seine Einwirkung auf die Küstengewässer, woneben auch der cyklonische Reststrom der Nordsee von Bedeutung sein dürfte. Eine Untersuchung der Angelegenheit unter den einfacheren Verhältnissen des offenen Ozeans wäre sehr erwünscht.

E. H.

H. W. Harvey. "Note on selective feeding by *Calanus*." Journ. Mar. Biol. Assoc., Vol. XXII, No. 1, pp. 97—100, 1 fig. Cambridge, 1937.

Es werden die Ergebnisse einiger Versuche mitgeteilt, welche den Untersuchungen über das Verhalten von *Calanus* zu kleinen Körpern (Karminpartikeln, *Nitzschia*) gegenüber sein Verhalten zu grösseren Diatomeen als Nahrung betreffen. Drei Experimente beziehen sich auf die Frage, ob Tiere von *Calanus*, die eine Woche lang bei bestimmter Diatomeennahrung gehalten wurden (*Ditylium* oder *Lauderia*), dadurch in ihrer Nahrungswahl aus einer ihnen danach dargebotenen Mischnahrung beeinflusst werden. Das scheint nicht der Fall zu sein. Dagegen geht aus diesen und einem vierten Experiment hervor, dass die drei genannten Diatomeen in sehr verschiedenem Grade, also mit Auswahl gefressen werden.

E. H.

M. V. Lebour. "The newly hatched larva of *Spirontocaris spinus* (Sowerby) var. *lilljeborgi* Danielssen." Journ. Mar. Biol. Assoc., Vol. XXII, No. 1, pp. 101—104, 1 fig. Cambridge, 1937.

Die Larve wird beschrieben und mit denen anderer Arten der Gattung verglichen.

E. H.

M. V. Lebour. "The eggs and larvae of the British prosobranchs with special reference to those living in the plankton." Journ. Mar. Biol. Assoc., Vol. XXII, No. 1, pp. 105—166, 4 figs. Cambridge, 1937.

Die Arbeit stellt eine übersichtliche Zusammenfassung des gesamten Wissens über den Gegenstand dar. In der Hauptsache besteht sie demgemäss aus Beschreibungen der einzelnen Arten, jeweils mit Angabe der Literatur und mit vielen Bemerkungen über das Vorkommen der Larven im Plankton insbesondere bei Plymouth. Die Einleitung enthält eine knappe Übersicht über die Entwicklung der Literatur, sowie eine Zusammenstellung von Beispielen, die zeigen, dass die Lebensweise der Erwachsenen keinen Anhalt über die der Jugendformen gibt, ob sie planktonische Larven sind oder nicht. Der Bearbeitung der einzelnen Arten geht eine kurze gruppenweise Zusammenfassung der Eier- und Larvenformen innerhalb der drei Ordnungen der Prosobranchier voraus, die zur ersten Orientierung in der Fülle der Formen von grossem Nutzen sein dürfte.

E. H.

P. M. Jenkin. "Oxygen Production by the Diatom *Coscinodiscus excentricus* Ehr. in Relation to Submarine Illumination in the English Channel." Journ. Mar. Biol. Assoc., Vol. XXII, No. 1, pp. 301—343, 9 figs. Cambridge, 1937.

The amount of photosynthesis occurring naturally in the sea has frequently been measured, but in few cases has an attempt been made to correlate photosynthesis with exact measurements of the energy of illumination at different depths. In the present paper the author used a pure culture of the diatom *Coscinodiscus excentricus* Ehr. and exposed it in glass bottles at different depths in the sea. The amount of photosynthesis was measured by the oxygen production. The illumination was measured by means of photo-electric cells and is expressed in terms of energy since the spectral composition of the light varies with depth, and, as the infra-red and the ultraviolet are rapidly absorbed, only the energy within the visible spectrum was measured. The total illumination over the time of an experiment was measured in the air, and the extinction coefficients of the violet-blue, green, yellow, and red light were calculated, sometimes by direct measurement with a photo-electric cell, and sometimes by derivation from a Secchi disk reading. Corrections were made for the loss by reflection and for the distribution of cloud. The energy is expressed in joules (1 joule = 0·24 gm. cal. per cm.^{2} per hour).

All the experiments were made in July and August, three for short periods about midday, two for nearly 24 hours, and one for a series of exposures over 24 hours.

A general relation between energy and oxygen production was found. When the energy flux was below about 7·5 joules there was a straight-line relationship between the energy and the amount of photosynthesis and the utilization was about 7 % of that available. Above 7·5 joules oxygen production was less regular though it continued to increase up to 20—30 joules. Above this there was a decrease owing to the injurious effect of sunlight. The energy in the illumination at the compensation point (about 45 m.) was about 0·55 joules, which lies very close to the value found for compensation intensity by Pettersson and his co-workers for mixed marine plankton. *Biddulphia regia* was found to behave in the same way as *Coscinodiscus*.

The methods used and the results obtained are critically examined and compared with those of other workers.

In a short appendix Dr. L. H. N. Cooper gives analyses of the phosphorus and nitrogen content of *Coscinodiscus*.

S. M. M.

F. S. Russell. "The Plymouth offshore Medusa Fauna." Journ. Mar. Biol. Assoc., Vol. XXII, No. 2, pp. 411—440, 5 figs. Plymouth, 1938.

This paper is mainly an account of the Medusae, chiefly Hydromedusae, captured off Plymouth in the weekly hauls of the 2-metre ring-trawl which have been made regularly since 1930. The species which have occurred are considered in their relation to the three main types of water which may at different times fill the mouth of the Channel. These three types have been defined in previous papers of Mr. Russell, after their characteristic fauna, as "Channel" (*Sagitta setosa*) "Elegans" (*Sagitta elegans*) and "Oceanic" (Salps and doliolids). Of the fifty-three species of medusae which form the total medusa fauna of the Plymouth marine area, thirty-four are here provisionally classed as indigenous and nineteen as visitors. It is the latter

which naturally can be used as indicators; the indigenous species, being the product of locally fixed hydroid stages, are always present in larger or smaller numbers. The presence of the hydroid stage is, however, not always a criterion of domicile, for as the author points out, there is a possibility that a visiting species may effect a temporary colonization if the hydrographic conditions remain favourable.

Of the three types of water the "elegans" water is the most productive of visiting medusae, the oceanic species being of rare occurrence and the "Channel" water being credited with only one, *Turritopsis nutricula*, which was absent in the three years, 1930—2, in which "elegans" water was predominant.

In addition to the tables of ring-trawl catches during the eight years and a table of Plymouth medusa giving the months of occurrence and abundance, the paper contains notes on the biology and structure of a number of species. One of these, *Aglantha rosea*, is remarkable in being characteristic of both "oceanic" and "elegans" water. Of this fact Mr. Russell suggests an explanation based on measurements made throughout a year. The specimens taken early in the year were of large size and probably of "oceanic" origin. These gave rise, by breeding in "elegans" water (*Aglantha* being a species which develops without an intermediate fixed stage), to a number of successive generations which matured at a much smaller size.

G. P. F.

F. S. Russell. "On the Seasonal Abundance of Young Fish. V. The Year 1937." Journ. Mar. Biol. Assoc., Vol. XXII, No. 2, pp. 493—500, 4 figs. Plymouth, 1938.

This, the fifth of Mr. Russell's reports on the ring-trawl catches of young fish at Plymouth, gives the catches for 1937 and compares them with those of previous years. It also suggests a correlation with the prevailing type of water, as indicated by the other inhabitants of the plankton. The catches for the three years 1935, 1936, and 1937 show that the rapid fall in total numbers of young fish from the high levels of 1930 and 1931 has been checked, and for these three years the numbers, though low, are uniform, with a slight tendency to increase amongst the summer spawners.

As these changes in the numbers hold good for uncommercial fishes, such as gobies and dragonets, as well as those which are commercially fished for, it is probable that the fluctuations are not due to human agency. Mr. Russell's suggestion, made in a previous paper, is that the scarcity of phosphates, due to the weakened flow of water from the west since 1931, is responsible. The conditions in 1937 lend further support to this theory, for, according to the summary of the occurrence of plankton "indicators" which is included in the paper, the water characterized by *Sagitta elegans* was scarce in the early part of the year and absent for the last five months.

The unusual abundance of young *Serranus cabrilla*, a southern species, in August and September 1937 is of interest. Their appearance coincided with the presence in some numbers of the siphonophore *Muggaea* and was followed shortly by an incursion of salps. If this indicated an influx of oceanic water it was evidently too late to remedy the phosphate shortage.

G. P. F.

Ad. S. Jensen. "Den kinesiske Uldhaandskrabbe (*Eriocheir sinensis* M.-Edw.) i Danmark." Kgl. Danske Vidensk. Selskab, Biol. Medd., XIII, 3, pp. 1—23, 2 pls. København, 1936.

L. F. Kamps. "De Chineesche Wolhandkrab in Nederland." Proefschrift. pp. 1—112, text-figs., 1 map. Leens, 1937.

E. Leloup. "La propagation du crabe chinois en Belgique pendant l'année 1937." Bull. Mus. Roy. d'Hist. Nat. Belgique, XIV, pp. 1—25. Bruxelles, 1938.

The Grapsoid crab *Eriocheir sinensis* Milne-Edwards, for which the name "Mitten crab" seems to have been generally adopted in English, is now widely distributed in many of the river-systems of northern Europe. The history of its spreading in the fresh waters of Germany was fully recounted in the well-known monograph by Peters, Panning and Schnakenbeck in 1933. The three papers quoted above continue the story for Denmark, Holland, and Belgium respectively.

In Denmark, as Jensen records, a specimen was found as early as 1927 on the west coast of Jutland. Thereafter there are no records till 1933 when a second was found on the same coast. In 1934 and 1935 specimens occurred, singly or in small numbers, at many places not only in Jutland but on the islands in the Baltic. Jensen notes that all the individuals found have been full grown but that they include no egg-bearing females so that it is uncertain whether the species has bred in Danish waters. It also remains to be seen whether the crab will continue to occur sporadically or will increase in numbers sufficiently to become a pest as it has done in Germany.

In Holland, the crab was first observed in 1931, although it is probable, as Kamps points out, that it had penetrated as early as 1928 into some of the waters communicating with the Rhine. In the years following 1931, however, it appeared in great abundance in the canals of the provinces of Groningen and Friesland, having apparently made its way in, not from the estuary of the Ems but from the Lauwerszee. The rapid increase in this district seems to have been due to exceptionally favourable conditions during the breeding periods of 1932—33 and 1933—34. After the latter year the eggs carried by the females were generally found to be dead and often attacked by a saprophytic fungus. As a result there was a rapid diminution in the numbers of the crabs in 1935 and 1936. In the Rhine district, on the other hand, although there has been some variation in numbers, the general result has been a steady increase owing, as Dr. Kamps believes, to the more gradual transition from salt to fresh water and the greater stretches of brackish water suitable for the breeding of the crabs.

Dr. Leloup continues the careful records for Belgium given in the same periodical last year. During 1937 the crab increased its area of distribution considerably and now occupies the whole water system of the maritime plain, limited on the south by a line passing through Ostend, Bruges, Ghent, Brussels, and Turnhout. It is pointed out, however, that the crabs of large size, which alone are to be expected further inland, tend to keep to the deeper parts of the rivers and thus escape notice. Females have been found carrying eggs in brackish water canals with a salinity of about 20 $^0/_{00}$. The interesting observation is made that rats are efficient natural enemies of the crabs, which they devour with avidity.

W. T. C.

E. Ford. "Vertebral Variation in Teleostean Fishes." Journ. Mar. Biol. Assoc., Vol. XXII, No. 1, pp. 1—60, fig. 1—18, Pl. I—XVI. Cambridge, 1937.

Die Tatsache, dass bei der Wirbelsäule der Knochenfische so viele schwer zu klassifizierende Varietäten vorkommen, war die Veranlassung für eine sehr gründliche Untersuchung dieses wichtigen Teiles des Fischskeletts und eine Beleuchtung der mit ihr zusammenhängenden Fragen nach den verschiedensten Richtungen hin. Der praktische Gesichtspunkt der Arbeit war die Verhinderung von Irrtümern und die Vermeidung von Missverständnissen bei der statistischen Auswertung von anatomischen Daten bei der Untersuchung von Fischpopulationen. In seiner fleissigen und gewissenhaften Untersuchung kommt der Verfasser ganz besonders zur Beachtung der Abhängigkeit der anatomischen Formbesonderheiten von der Funktion und liefert so wertvolles Material für eine "funktionelle Anatomie", die schliesslich übergehen wird in eine "biologische Anatomie" der Fische.

Zuerst gibt Verf. eine Untersuchung der Frage, inwieweit man von einem *Halsabschnitt* sprechen kann, d.h. ob bei Fischen ein dem Atlas und Episthropheus der Landwirbeltiere entsprechender Abschnitt zu erkennen sei. Er geht dabei von der Wirbelsäule von *Gadus* aus, bei dem die 4 ersten Wirbel zweifellos einen eigenen Charakter besitzen. Es folgen die Beziehungen der Wirbelsäule zur *Schwanzflosse*, die nicht nur an der Wirbelsäule einen Halt findet, sondern die beide zusammen eine für die Voranbewegung ausserordentlich wichtige "anatomische Konstruktion", wie Referent es ausdrücken würde, bilden, während die Beziehungen der Wirbelsäule zu den übrigen unpaaren Flossen wesentlich einfacherer Natur sind. Weitere kurze Abschnitte behandeln die topographisch-konstruktiven Beziehungen zu den *Eingeweiden*, zum *Zentralnervensystem* und zu den grossen *Blutgefässen*. Es wird dann angedeutet, dass man die Wirbelsäule auch mit den Augen des Ingenieurs auf mechanische Besonderheiten untersuchen sollte, und dass ein reiches Ergebnis die Folge sein würde. Es folgen Bemerkungen zum *Sexualdimorphismus*, denen eine interessante Abbildung der Verschiedenheiten des Hämalbogens bei dem männlichen und weiblichen *Labrus berggylta* beigegeben ist. Ein kurzes Kapitel wird der Schätzung des *Alters* aus den Knochenstrukturen gewidmet und dabei auf "Wachstumsringe" hingewiesen. Das umfangreichste Kapitel jedoch ist das über die *Zahl der Wirbel*, die ja die grösste Variabilität erkennen lässt.

Die zweite Hälfte des an Anregungen und Einzelergebnissen reichen und sehr gut bebilderten Buches enthält eine Besprechung der Taxonomie und Phylogenie der Wirbelsäule bei einer grösseren Anzahl von Knochenfischordnungen.

Das Buch wird zweifellos dazu beitragen, die wesentlichen von den unwesentlichen Tatsachen unterscheiden zu lernen und den Blick für die biologisch-morphologischen Zusammenhänge zu schärfen.

Hans Böker.

M. B. Schaefer. "Contribution to the Life History of the Surf-Smelt, *Hypomesus pretiosus*, in Puget Sound." Dept. Fish., State of Washington, Biol. Rep. No. 35B, pp. 45, 33 figs. Seattle, Wash., 1936.

This is a very satisfying study of a fishery of great local importance in Puget Sound, on the Pacific coast of the United States. The surf smelt is very easily fished, from the beach, with inexpensive gear, and is in great demand; it is, therefore, very vulnerable to overfishing, and the yield has, in fact, been declining.

Except for a small fishery for immature smelts in the Bellingham area in March, the commercial fishery takes place entirely on spawning fish. Spawning takes place on one or another of the beaches in Puget Sound in practically every month of the year, though the season on any one beach usually lasts from two to four months only. The smelts spawn near high water, on the ebbing tide, and most often on the late afternoon and evening tides. The location of the spawning places is related to a particular size of gravel, to which the eggs adhere, and to the degree of shading of the beach by trees. The shoals, therefore, come to within a few yards of the water's edge, and are very easily enclosed by shore seines, and even caught with hand nets; the latter is an attraction to sportsmen and tourists.

A single fish may spawn repeatedly during the season; this is shown by a study of the ovarian eggs. The fecundity of the female increases in linear relation to the length of the fish; an increase of 1 cm. in length increases the fecundity by about 4,000 eggs. A large female may produce about 30,000 eggs, and it is of great interest to learn that the larger females produce larger eggs than the smaller females. These points illustrate the importance of the larger fish in maintaining the stock.

The smelts make no attempt to bury their eggs, but the slight shifting by the waves of the gravel on which they are deposited suffices to bury them an inch or two beneath the surface. The eggs are deposited where they shall be immersed daily or twice daily by the incoming tides, and have water over them when the larvae are ready to hatch.

This fish has a short life-history. Sexual maturity sets in at one year of age, the bulk of the commercial catches consist of the two year old fish, and no fish older than three years were found.

A racial analysis of the stocks from different spawning beaches was made; the rather surprising result emerged that in Puget Sound a number of races of smelt occur, which are distinguished by the number of vertebrae, and by differences in the rate of growth. These races tend to be kept apart by the differences in their spawning seasons. It will be recalled that Schmidt found great differences in the number of vertebrae in *Zoarces viviparus*, which also lives in small inlets of the sea.

In the light of his results the author comments upon the present fishery laws of the region. These afford protection to only two of the important spawning beaches during a part of the spawning season only. Now, these two beaches yielded a weight of smelts greater than all the other beaches put together, and the author is clearly of opinion that this is a consequence of the protection given, and that a similar protection given to the other beaches would be of great benefit to the conservation of the stock. The occurrence of local races means that the protection given to certain spawning beaches does not benefit the others.

This paper studies, in miniature, as if on the laboratory scale, the manifold problems presented by every fishery; the results have been obtained by well-conceived observations, adequately tested by recognized statistical methods. The reviewer's only criticism is that a map should have been included.

C. F. H.

Chr. Hessle. "Undersökningar över strömmingen i Stockholms skärgård." Svenska Hydrogr.-Biol. Komm. Skr., N.S., Biol., Bd. II, Nr. 2, pp. 21, 2 figs. Stockholm, 1937.

The author makes a new and interesting contribution to the study of the Baltic herring. The investigations were carried out during the years 1932—

1935 and relate to a particular area off the Baltic coast of Sweden, namely, the archipelago off Stockholm with its thousands of islands separated by narrow inlets or by wider waterways. The large quantity of fresh water which is carried out from Mälaren overlies the salt water as brackish surface layer, which in the innermost parts has a salinity of only 1 or 2 $^0/_{00}$. As a consequence, the vertical circulation of the water there is rendered more difficult and the surface layer reaches a very high temperature in the summer months, while the lower layers are still very cold. Another consequence is a rather low amount of oxygen in the lower water layers in these parts of the area, which is to a great extent also caused by the pollution from Stockholm. The plankton fauna of the area must be considered as very rich from a quantitative point of view, and the macroplankton consists chiefly of crustaceans which are the main food of the herring in this district. The very large herrings, however, feed on bottom animals and small fish, and the author is of opinion that the rapid growth of these herrings is due to the fact that they have abandoned the plankton for a more substantial diet. With the exception of these large herrings, which may attain a length of 34 cm., most of the fish in the catches generally have a length of 14—19 cm. A survey is given of the average length of the 2—5-year-old herring from different parts of the archipelago. The rapidity of growth is somewhat greater in the outer than in the central and innermost parts of the area. The herrings for the most part become ripe at the age of two years. The spawning season lasts from the latter part of April to the beginning of July, and generally the water on the spawning grounds is rather shallow. Very few herrings spawn in the innermost parts of the archipelago where the temperature of the water, except that of the surface layer, is very low, and the herring fry are very scarce there. The main spawning places are situated in the outer and central parts, but there is an inward migration of the herring which have finished their spawning. During the winter the herring seem to stay in the deeper parts of the central and outer districts. In an earlier paper (1925) the author has shown that there exist several local races of herring in the archipelago and the bays of the Baltic coast of Sweden, which he calls Baltic fjord herring and which are all spring spawners and characterized by a very low number of vertebrae. The herrings in the archipelago of Stockholm are also typical fjord herrings and the mean number of vertebrae fluctuates between 55·09 and 55·18. The author has earlier shown that the number of vertebrae of the spring-spawning herring in the open sea off the Baltic coast of Sweden is about 55·5. The outermost part of the archipelago can be considered as a transition area between the archipelago proper and the open sea, and the average numbers of vertebrae of the herrings in three different catches in this region were 55·32, 55·25, and 55·21. The author is therefore of opinion that the herring in the outermost parts of the archipelago must be considered as intermediate forms between the sea herrings and the fjord herrings. All spring herrings along the middle and southern Baltic coast of Sweden belong, according to the author, to the same progeny which as regards number of vertebrae, rapidity of growth, and other characters, shows a great variety in adaptation to the conditions in the different localities of its area of distribution.

Sven Runnström.

A. L. Tester. "Some Results of the British Columbia Herring Investigation and their Economic Bearing." Rep. British Columbia Comm. of Fish., 1935, pp. L74—L80, 3 figs. Victoria, B.C., 1936.

The immediate purpose of these investigations was to determine whether fishing activity was sufficiently intense materially to reduce the available supply and endanger the future of the fishery. Since 1929 several articles dealing with various phases of the investigation have been published. In 1936 the author published two scientific papers in the *Journal of the Biological Board of Canada* dealing with local populations of herring, and with length and age composition of the runs; in the present article he reviews the more important results and their economic bearing. Vertebral counts show that the average number increases more or less regularly from south to north along the coast and this gradation is probably related to a gradation in water temperatures, the water becoming progressively colder from south to north. The keeled-scale counts show a similar but opposite gradation. The presence of these gradations and their persistence from year to year proves that extensive intermingling of the herring of the various runs along the coast does not take place and that various "local populations" are present in the waters. Apart from the seasonal movements which must take place, the herring of British Columbia thus appears to be essentially a non-migratory species. Annual fluctuations or long-term trends in abundance, whether due to "natural" causes or to fishing activity, will therefore not necessarily be widespread throughout all areas.

The study of the length and age composition forms an important phase of the herring investigations in British Columbia. Ages range from II. to XI. or more, but the bulk of the catch is made up of fish of ages III. to VI., inclusive. However, a considerable diversity in age composition is found between different localities and this peculiar condition is doubtless related to the tendency of the Pacific herring to form local populations. Successive broods of herring vary in relative abundance from year to year to some extent, but the richer year-broods predominate in the catches for shorter periods, as compared with herring in other great fisheries. These peculiarities are the result of a high rate of natural mortality in the British Columbia herring. Over a twenty-year period a decrease in average length and in average age has been noted both on the south-east coast of Vancouver Island and in Barkley Sound. According to the author the more plausible interpretation of this phenomenon is an increased mortality imposed on the stock in these two areas by fishing activity, and it seems advisable to guard against an intensity of fishing similar to that which occurred between 1925 and 1929 until the optimum level of fishing has been determined by scientific research.

Sven Runnström.

R. Seiler. "Die Fütterung des Karpfens, beurteilt nach Aquarienversuchen." Internat. Rev. d. ges. Hydrobiol. u. Hydrogr., Bd. 36, Heft 1/2, S. 1—56. Leipzig, 1937.

Although breeding of carp in artificial ponds can be traced back over 1,000 years in Central Europe there is still a considerable amount of controversy as to the principles of nutrition and feeding. As late as the 18th century only have attempts at artificial feeding in a very haphazard way been recorded. Ever since, with an increasing knowledge of the natural food of the carp in connexion with an application of general principles of nutrition, work has been done to improve the crop of this important food-fish.

A great variety of substances of plant and animal origin has been added to the ponds with occasional success in increasing the crop of carp. It was left undecided, however, if and to what extent the artificial food-substances were actually taken up by the fish or whether by affecting the general condition of the pond the supply of natural food was thus increased.

It was not until planned experiments in ponds at Wielenbach, in South Germany, were started, round about 1900, that the relationship between food-substances and the crop of fish was investigated carefully. These experiments, which are the starting-point for the paper under consideration, showed the great importance of the correct balance between natural food already available in the pond and the quantity and quality of artificial food added. Work with an experimental pond, however, is necessarily confronted with very complex conditions only partly under control and results are bound to be tentative.

It seemed desirable, therefore, to test various conclusions reached in field experiments, under controlled conditions, working with isolated fish in tanks. 166 carp were used in 6 series of experiments. Known quantities of food were added, the fish were weighed and measured at given intervals, each series lasting about three months. Comparison of some of the results obtained is made difficult because of the seasonal fluctuations in the water temperature, as there was no control available. Future experiments should certainly arrange for steady temperatures, especially in view of the temperature relation of digestion, as pointed out by various authors working with fish. "Natural" food, *Daphnia* and "rote Mückenlarven" (most likely Chironomid larvae, though no Latin name is given) were used and their effect compared with artificial foods such as rough-ground soya or lupines, potato-flakes, and fish- and blood-meal. A table of chemical analyses of the various foods used is given.

It has been found that ground soya beans yielded by far the best result as tested by the weight increase of the fish in a given time. This contradicts statements that the carp must necessarily be provided with a certain proportion of "natural" food. All that is necessary is a certain balance between proteins and carbohydrates in the diet, the derivation of which seems to be unimportant. It has been shown both by these and by test-tube experiments (V o n k, 1927) that the carp can produce the right ferments for the digestion of pure vegetable food and that ferments introduced by animal food are not essential.

A number of artificial food mixtures proved to be more efficient than *Daphnia* or Chironomid larvae alone, again due to the more favourable carbohydrate-protein ratio. Fishmeal as a source of protein proved more effective than other animal meals, when added to simple carbohydrates. It is of interest that experiments with yeast (Cenovitanhefe) added to potato-flakes, which alone are a very inferior food, proved to be very successful when the amount of yeast added did not exceed 1/20. When added in larger quantities the proteins introduced with the yeast had a clearly negative influence, resulting in only a very slight weight increase of the fish, compared with experiments without yeast. This conclusion as to the inhibiting effect of high protein doses has been reaffirmed in various series of experiments with other sources of protein than yeast. For carp of under a year's age the best ratio in all the experiments was carbohydrates: proteins as 5:1. Addition of lime in varying quantities proved to be of no traceable effect.

These experiments have certainly cleared away a number of misconceptions and misunderstandings and have demonstrated some of the principles for the nutrition of the carp. Their application in practical cases will,

however, not be easy, as this must always depend on an estimation of the natural food present in a given pond. This is one of the two important factors, the protein supply, which must be correctly balanced with the carbohydrate supply, provided artificially, in order to obtain a maximum output.

M. Rosenberg.

J. H. Orton, J. W. Jones and G. M. King. "The Male Sexual Stage in Salmon Parr (*Salmo salar* L. Juv.)." Proc. Roy. Soc. London. Series B, Vol. 125, No. 838, pp. 103—114. London, 1938.

That young male salmon, not yet old enough to migrate to the sea, are occasionally sexually mature has been known for a very long time but hitherto the phenomenon has never been properly investigated. Last autumn, however, Orton and his co-workers examined a considerable number of salmon parr from the Welsh Dee.

Of 226 fish examined, 94 were ripe or ripening males, 94 immature females and 38 of doubtful sex, probably immature males. The fish were mainly a few months less than two years old, though a few were one year older. The authors conclude that "The evidence is therefore not sufficient to permit the statement that *all* male salmon parr pass through a functional sex-phase in fresh water, but there is no doubt that the greater proportion, and possibly all, do so."

They have also shown experimentally that sperm from these males is capable of fertilizing successfully eggs from adult females and they record spent males amongst the smolts in the Dee in May 1937. As male parr have frequently been observed consorting with adult female salmon on the redds, there is a distinct possibility that they fertilize the eggs. The authors suggest that in most rivers there may be enough young males to fertilize all the eggs produced by adult females. This possibility raises some interesting speculations particularly as to the role of adult males, which "may not be simple".

Such differences in size and age between functional males and females are, so far as is known, unparalleled in other fishes and the authors compare this condition with early sexual maturity in the oyster and other molluscs.

Whilst this paper records a great advance it is preliminary to further investigations and many questions still remain to be answered. For instance smolts, apparently ripe males, have been recorded in May, six months after the normal spawning season of the adults and it is therefore not yet certain that male parr always mature at the normal breeding season. The discussion of such matters is, however, premature, for all those interested in salmon biology will await with great interest the further papers promised us on this subject, and when the whole story is told there is no doubt that a great addition to our knowledge of the salmon will have been made.

F. T. K. P.

W. E. Ricker. "The Food and the Food Supply of Sockeye Salmon (*Oncorhynchus nerka* Walbaum) in Cultus Lake, British Columbia." Journ. Biol. Board. Canada, Vol. III, No. 5, pp. 450—468, 5 figs. Toronto, 1937.

This paper deals mainly with the diet of sockeye salmon in their first year, though a few in their second, third, and fourth years were also examined. It was found that pelagic Crustacea belonging to the genera *Epischura, Cyclops, Bosmina,* and *Daphnia* form practically the only food

of the youngest fishes and the principal food of the others. The older fish also eat significant quantities of midge pupae and a few of the largest were found to have eaten very small fish.

When all the data are grouped together it appears that the extent to which any planktonic species is used as food is dependent on (1) its abundance in the lake; (2) its size, the larger forms being more readily eaten than the smaller (there is an error in the abstract which heads the paper, for it is there stated that the "percentage utilisation varies .... *inversely* as the size"); and (3) its habitat, for in the summer sockeye apparently live in the region of the thermocline and animals living high in the epilimnion or low in the hypolimnion are comparatively safe from attack. It is very likely, too, that food selection by the fish is important, for at times individuals certainly pick out one species and ignore another and in general *Bosmina* is much more regularly eaten than *Cyclops* though they are much the same in size, abundance, and habitat.

The amount of food eaten varies seasonally, being highest in summer and lowest in winter and it follows closely the seasonal abundance of the plankton.

Although other species of fish in the lake are also plankton feeders, Ricker shows that owing to differences in habit, interspecific competition for food is of minor importance to the salmon but in years when the crop of young sockeye is abundant, intraspecific competition is not only sufficient to reduce considerably below normal the amount of plankton in the lake in late summer, but also to decrease the normal growth-rate of the fish.

The author concludes that the seaward migration of the young fish has no relation to food supply, for it occurs at a time when the amount of food is rapidly increasing, a factor which is worth emphasizing in view of the theory that the object of migration in salmon is to exploit the more abundant food in the sea.

In the third paragraph on page 454 a line has become misplaced, making this paragraph at first sight difficult to understand, but the paper is well written and the facts and deductions are clearly set out.

F. T. K. P.

R. E. Foerster. "The Relation of Temperature to the Seaward Migration of Young Sockeye Salmon (*Oncorhynchus nerka*)." Journ. Biol. Board Canada, Vol. III, No. 5, pp. 421—438, 3 figs. Toronto, 1937.

This is another excellent paper in the series on the sockeye salmon from the Cultus Lake laboratory, where a well-designed programme of research continues to yield results of great interest and importance.

This time the subject of discussion is the seaward migration of the young sockeye in the spring. The author shows that there is a statistically significant correlation between the water temperature in the months preceding the migration and the time of the seaward run. The correlation is negative, the lower the temperature in January, February, and March, the later the migration. The fish generally begin to travel seaward when a threshold temperature of 4·4°C. is reached, but in seasons when the water is abnormally warm throughout the winter a slight rise appears to be necessary before migration starts. The rate of migration, once it has begun, seems to depend mainly on the weather conditions prevailing at the time and their effect on the limnological conditions in the lake. Most fish appear to migrate on bright, calm days.

It appears that migration ceases when the surface water temperature reaches 10°C., and Foerster believes that this is due to the fish which

have not yet gone to sea seeking the cooler water in the depths of the lake where, of course, they are cut off from the outlet. A similar theory has been used by W a r d (Proc. Nat. Acad. Sci. 18 (9) 1932) to explain the evolution of a race of landlocked salmon.

Most sockeye salmon migrate seawards from Cultus Lake when they are one year old, but a small proportion, probably derived from spawn deposited in or near the outlet stream, migrate as fry and some do not go until they are two years old. Again, not all the two-year-olds migrate, for a few, the largest, mature precociously in the lake. Three-year-old migrants are exceedingly rare. F o e r s t e r believes that those which stay in the lake until they are two years old are those which have not migrated as yearlings by the time the temperature barrier becomes established. He produces evidence to show that the reason why all the fish do not leave the lake as yearlings is that the migration urge is in some way connected with size. Those which have not attained a certain minimum size by the time the surface water of the lake rises above 10°C. cannot migrate for another year. A similar relation between size and the migration urge has also been suggested in Atlantic salmon (*S. salar*) but clearly the causal factors need a good deal more investigation.

In many features of its biology the sockeye resembles the Atlantic salmon and it seems likely that many of the findings recorded in this paper have a wider application, though our salmon smolts seem to migrate in wet weather rather than during fine spells and it is hard to see how the temperature barrier could explain the cessation of migration in such an essentially fluviatile species as ours. It would, however, certainly be worth while to investigate the relation of winter temperature to the smolt run in Atlantic salmon and we may look to further papers from Cultus Lake for other fruitful suggestions.

F. T. K. P.

A. H. Laurie. "The Age of Female Blue Whales and the Effect of Whaling on the Stock." Discovery Rep., Vol. XV, pp. 223—284, figs. 1—14. Cambridge, 1937.

In this paper an attempt is made to answer the following chief problems: — What is the span of a Blue whale's life? Is there any method of assessing the age of the Blue whale caught in pelagic whaling? What effect has whaling had on the stock of Blue whales in the Antarctic?

An investigation of the ovaries of the Blue females caught in pelagic whaling showed that the Blue female becomes mature at about the same size as has been found for the S. Georgia Blue female, namely at an average of 78 ft. There seems, therefore, to be no reason to suppose that the Blue whales taken in the Weddell, the Bouvet and the Kerguelen areas differ at all from those taken at S. Georgia in point of growth and sexual maturity. Further it is found that the foetal growth curve constructed on observations obtained in the pelagic whaling, is identical with the foetal growth curve constructed on observations from the S. Georgia stations. This shows similarity in the breeding habit between whales taken in pelagic whaling and those taken in S. Georgian waters.

The chief problem of the paper is to find a method by means of which an assessment of the age of the Blue whale female can be made. First the author tried to employ the same method which has been employed in the case of the Fin whale female. This method, which is based on the occurrence of peaks with regular intervals on the corpora lutea graph fails, however, in the case of the Blue whale female. But a comparison between the frequency

graph of corpora lutea numbers in two subsequent years showed an average increase of the number of corpora lutea of 1·13 in a year.

It has been found that whales from 78 to 81 ft., a group which there is reason to suppose is a year-group of newly mature animals, are found with an average of 1·91 corpora lutea. These results suggest that whales over two and under three years old have two corpora lutea in the ovaries. Subsequently there is an increase of little more than one corpus luteum in a year or, more exactly, an increase of eleven corpora lutea for every ten years.

It is shown that physical maturity does not occur in female Blue whales under 86 ft., but many whales grow much beyond this length. However, a correlation is found between the number of corpora lutea and the attainment of physical maturity. The onset of physical maturity in Blue whale females coincides with the accumulation of eleven corpora lutea in the ovaries. According to this and to the correlation between the age and the number of corpora lutea, physical maturity will be attained at ten to eleven years of age. The oldest Blue whale females in the material are of the order of thirty years of age. These females do not, however, show any sign of diminishing fertility, and the author suggests that this is due to the present condition that the Blue whales are unable to survive long enough to reach a climacteric.

In the last chapters of the paper we find a discussion of the actual problem of the situation of the Blue whale stock in antarctic waters. In the opinion of the author the nature of the curve illustrating the age distribution of adults indicated by the frequency graph of corpora lutea numbers suggests that there has been a progressive diminution in the rate of recruitment of recent years. The present rate is thought to be insufficient to maintain the stock of Blue whales under the present intensity of whaling operations. It is assumed that if a constant stock is subject to constant birth- and death-rates, the number of living in year-groups will take the form of a decreasing geometrical progression.

In the final pages attention is drawn to the well-known fact that the average length of the Blue whale has fallen off year by year and that the percentage number of immature animals has increased in the last years. The method of presenting these facts used in the Norwegian investigations has been criticized. Both facts have been stated by the author as being proofs of a dangerous diminution of the stock.

Per Ottestad.

L. H. Matthews. "The Humpback Whale, *Megaptera nodosa*." Discovery Rep., Vol. XVII, pp. 7—92, Pl. II. Cambridge, 1937.

This paper is a valuable contribution to the series of Discovery Reports devoted to the morphology and biology of whales.

The staff engaged in this part of the Discovery Investigations has confined its activities to South Georgia and South Africa and the number of Humpbacks which it has been possible to observe is, therefore, somewhat small, not more than 62 in all. The author, however, makes extensive use of the statistics referring to this species.

In the first part of the paper the author discusses the sex proportion in the catches, and for this purpose 1,680 Humpbacks are considered. In seasons showing a fair catch of Humpbacks the percentage of males varies between 35·1 and 59·4, less than 50 per cent. in South Georgian and generally more than this in the South African catches.

In order to establish the variation in the external characters of Humpback

whales, a great number of different measurements have been taken and the results are set forth in tables and diagrams. One table (Table IV) is devoted to the calculated mean values in respect of 18 different measurements from males and females at South Georgia and South Africa respectively, expressed as percentages of total lengths. The number of measurements is small, particularly in the case of those from South Africa, but the author may safely conclude from the data obtained that "there is no indication of any racial difference between whales from the two places ....".

The classification of the coloration of the Humpbacks enables a comparison to be made with the results obtained by Lillie in his investigations in New Zealand during the Terra Nova Expedition. In South Georgia and South Africa dark coloration of Humpbacks prevails, about 60 per cent., of the total number under consideration being found in colour-group 4, embracing the darkest animals which are nearly black all over. In New Zealand extremes of coloration were rare, most of the animals being classified in intermediate groups. "These colour differences," says the author, "point to the possibility of some degree of segregation between the South Atlantic, Indian Ocean, and New Zealand herds of Humpback whales."

In the section dealing with external characters the author further discusses the occurrence of hair, the number of ventral grooves, and the number and growth of the baleen plates. Mr. Matthews arrives at the important conclusion that in none of the characters considered can any differences from those of Humpback whales taken in the northern hemisphere be detected.

An investigation of the stomach contents shows that the whales taken off the coast of South Africa do not generally feed, although in two cases fish remains were found. On the other hand most of the Humpbacks taken at South Georgia contained *Euphausia superba*. In other waters Humpbacks feed on other crustaceans and on different species of fish.

The most interesting part of the paper is that devoted to the reproduction and growth of the Humpback whale. The procedure adopted in studying these questions has been the same as that followed by Mackintosh and Wheeler in their investigations on southern Blue and Fin whales (*Discovery Reports*, Vol. I, 1929) and previously reviewed in this Journal (Vol. VI, No. 1.)

We find, therefore, extensive data on the anatomy and histology of the external and internal sexual organs, the sexual cycle of the glands, and the frequency of corpora lutea in the ovary. The growth studies are accompanied by statistics of measurements of foetuses and of the animals caught in the different months.

The results obtained by Mr. Matthews may be summarized as follows:

The duration of gestation is, as for other baleen whales, about 11 months, and the young are born at a length of 4·5 to 5 m. The calf is suckled for 5 months, and grows during lactation to a length of about 8 m. At the age of twenty to twenty-two months the Humpback attains maturity, the length of the male being then about 12 m., that of the female about 12·5 m. Pairing may occur at any time of the year, but in the main it takes place during the period August—November. The Humpback usually breeds once in every two years, occasionally twice in three years. In this outline of the life history of the Humpback we observe a striking similarity to that of the Blue and Fin whale, the chief difference being a shorter period of lactation and (possibly therefore) more frequent breeding. The Humpback reaches physical maturity, as shown by the ankylosis of the epiphyses of the vertebral column, at about the age of 10 years.

The author further reviews the facts available concerning the migrations

of the Humpbacks. More clearly than for any other species can the seasonal migrations between temperate and cold seas be demonstrated, although these migrations do not include all Humpbacks.

In the last section of his paper Mr. Matthews draws attention to the heavy decline in the stock of Humpbacks wherever it has been hunted, a decline which must be attributed solely to excessive slaughter. Concerning this important fact, he is safe in concluding that the stock can only regain its former abundance if the Humpback is afforded world-wide protection for a long period of years.

Johan T. Ruud.

J. Hjort, J. Lie and J. T. Ruud. "Pelagic Whaling in the Antarctic. Nr. VI, the Season 1935—6." Hvalrådets Skr. Nr. 14, pp. 1—45, text-figs. 1—7, plates I and II. Oslo, 1937.

"Pelagic Whaling in the Antarctic. Nr. VII, the Season 1936—7, with a Preliminary Report on Variation in the Size Distribution of Blue and Fin whales, by Per Ottestad." Hvalrådets Skr. Nr. 18, pp. 1—68, text-figs. 1—15, plates I and II. Oslo, 1938.

In these two papers the authors continue for the seasons 1935—6 and 1936—7 their valuable series of analyses of whaling statistics. The data upon which these analyses are based are extracted from the journals sent in yearly by the whaling factories to the Biological Laboratory at the University of Oslo. The analyses are carried out upon the same general plan for every season with comparable tables, graphs, and charts, which make it possible to study the monthly and seasonal fluctuations of the catches. As in all previous papers in this series the movements of the whaling fleet in each of the two seasons under consideration have been plotted upon charts in which the Southern Ocean, south of latitude 50°S., has been divided into five areas of whaling activity. From these it is seen that exceptional ice conditions in the season 1936—7 led to an unusual distribution of the whaling fleet during the middle part of that season.

During the season 1935—6 both the Norwegian and British Governments restricted the fishing by vessels flying their respective flags to the period December 1st to March 15th. There was also a voluntary agreement reducing the catch to definite quotas related to the capacity of the individual factories. Part of the whaling fleet was laid up throughout the season. A *pro rata* allowance was paid by the operating companies into a "laying up fund" out of which compensation was paid to the companies whose ships were kept idle during the season. In order to compensate for the shortness of the season the average number of catchers per expedition was increased. During 1936—7 both governments further restricted whaling south of latitude 40°S. to the period December 8th to March 7th. The number of catchers was restricted for certain types of factories.

In previous discussions of whaling results the authors have used certain standards by which the individual seasons or areas, or the activities of the various expeditions, were compared. These were, for instance, the "Blue Whale Unit", expressing the relative value of the different species of whale, and the "Catcher's Day's Work", expressing whaling activity in units of time. These standards, however, as the authors point out, are tending to lose their significance as measures of comparison as the technical development of the whaling fleet progresses. Nevertheless, while making due allowance for these limitations of their standards, the authors draw certain conclusions with

regard to the progress of whaling and its possible effect on the stock in the future. They make no attempt to minimize the gravity of the conclusions at which they have arrived.

In discussing the species composition of the catch they point to the steadily decreasing relative toll of Blue whales and the steadily increasing relative toll of Fin and other whales. Over the whole area where whaling has been carried on in recent years the percentage of Blue whales in the catch has declined from 70·2 % in 1933—4 to 42·8 % in 1936—7. The percentage of Fin whales in the catch has increased from 24·2 % in 1933—4 to 40·5 % in 1936—7. The increase in the proportion of "other whales", which means, in the main, Humpbacks, is equally striking. "Other whales" increased from 5·6 % in 1933—4 to 16·7 % in 1936—7. Humpbacks, indeed, seem now to be a fairly constant feature of the catch in the South Indian Ocean (Areas III and IV on the authors' charts). It is evident, then, that the good catches obtained in the seasons under review have been achieved only by means of "a continually increasing toll of the less valuable and previously neglected species."

The high percentages of immature Blue whales, especially in Areas III and IV, are also regarded as serious from the point of view of the renewal of the stock. It is pointed out that it is this increase in the proportion of immature animals in the catch which is responsible for the diminishing average lengths of both the Blue and Fin whales taken, rather than an actual decline in the size of the mature animals. This fact is brought out by the authors' method of tabulating separately the average lengths of the immatures and of the matures.

One of the most striking facts shown by the tables is the remarkable decrease in the average number of barrels of oil obtained per whale during the last two or three seasons compared with, say, the seasons 1930—1 or 1931—2. In those years the average number of barrels per whale obtained by the fleet as a whole was 91·2 and 106·5 barrels respectively. But in the two seasons under review it had declined to 78·4 barrels. As reasons for this the authors suggest the altered species composition of the catches and the decrease in the actual lengths of the whales taken. In spite of the fact, however, that it now seems impossible to count on a higher average yield per whale than this, yet "the average catch per expedition is still satisfactory in so far as it is large enough to assure the expeditions economically lucrative operations". Nevertheless it cannot be overlooked that the statistics "show very serious signs of a decrease of the stock of Blue whales, the most valuable species, and that production has only been maintained by an increased catch of the other, previously neglected, species, the Fin whale and the Humpback whale".

At the end of *Hvalrådets Skrifter* No. 18 there is appended a preliminary report by P e r O t t e s t a d on some investigations now in progress into the size composition of the stock of antarctic Blue and Fin whales and the fluctuations which take place in it. The report is so far only a provisional one and the investigations are by no means complete. It does no more, therefore, than establish the fact that very definite monthly, yearly, and geographical fluctuations do take place in the size composition of the stock. The author has taken a series of selected length-frequency curves for the various months, seasons, and areas and has shown on graphs how these frequencies deviate from certain standards such, for instance, as the length-frequency curve for the whole catch taken in a season or the average length-frequency over a stretch of seasons. He finds that in the south-west Indian Ocean (Area III) small- and medium-sized Blue and Fin whales commonly

predominate over the larger sizes. In the south-east Indian Ocean (Area IV) the larger sizes predominate, while the Weddell Sea area (Area II) occupies a position in respect of the sizes of the whales taken which is intermediate between the other two areas. The proportion of small whales increases as the season progresses, probably because the small whales arrive later on the grounds than the larger whales and also, perhaps, leave the grounds later. The graphs show also a remarkable change in the composition of the stock of both Blue and Fin whales in Area III in the last three seasons (1934—5, 1935—6, and 1936—7). In 1930—1, 1931—2, and 1932—3 there was a surplus of medium-sized whales and a deficit of the smaller sizes, but since 1934—5 there has been a deficit of the larger and a surplus of the smaller sizes.

In the present state of his investigations the author does not commit himself to any statement as to the causes of this change, or of the monthly and geographical fluctuations which he indicates, but does no more than record provisionally that they exist.

F. D. O.

J. F. G. Wheeler. "Further Observations on Lunar Periodicity." Contrib. Bermuda Biol. Stat. Research, Inc., No. 72. Journ. Linnean Soc., Zool.., Vol. XL, pp. 325—345, figs. 1—8. London, 1937.

Lunar periodicities in the swarming of marine organisms are usually associated with reproduction, and occur during the breeding season, but in the present paper Wheeler shows that certain prawns occurring at Bermuda show a lunar periodicity of occurrence at the sea surface throughout the year. These prawns are *Anchistioides antiguensis, Penaeopsis goodei* and *P. smithi,* and there is evidence that *Penaeus brasiliensis, Periclimenes americanus,* and *Leander affinis* behave in a similar way. The dates of most abundant appearance are the second and twenty-sixth nights of the lunar month, thus about the time of new moon, and swarming takes place for an hour or two after sunset, the appearance of the prawns being more sudden than their subsequent disappearance from the surface. The time of swarming varies with the time of sunset throughout the year.

Wheeler discusses the different factors which might control this well-defined and interesting periodicity. He shows that one of the prawns, at least, moults at regular intervals, the most frequent dates of moulting being the eighteenth to the twenty-second and again on the twenty-eighth day of the lunar month. Possibly the presence of the prawns at the surface a few days after the moult indicates increased activity following the enforced seclusion at the time of moulting. This would suggest an internal rhythm as underlying the cause of swarming; but Wheeler considers that external factors, especially the inhibitory action of light on these nocturnal forms, are the most likely. There is no correlation between the abundance of the prawns and the abundance of the polychaet worms on which they normally feed.

Wheeler's work introduces us to a new and well-authenticated case of lunar periodicity in marine organisms, the further study of which is promised, and should go far to clear up the factors underlying the periodicity at least in this group of organisms.

C. F. H.

R. W. Dodgson. "Shellfish and the Public Health." Public Health, Vol. L, No. 9, p. 279. London, 1937.

The first part of this communication deals with the routine and principles of the process employed at the Ministry's shellfish purification stations at Conway (mussels) and Brightlingsea (oysters). The essentials are covered by a previous review in this journal[1]) and hardly require recapitulation. It is to be kept in mind that the process depends on the ability of the actively functioning shellfish *to cleanse itself*, physically and bacteriologically, in sterile sea water.

Bacteriological control of the process maintained intermittently over years established the rule that shellfish showing hundreds or thousands of lactose fermenting coliforms per 1 c.c. of standard emulsion when entering the tanks show 0—5 per 1 c.c. on despatch to the market. Suddenly in the season 1935—6 and over some 6 weeks, extremely high lactose fractor counts (900, even 1600 per 1 c.c.) were obtained from mussels which had passed through the cleansing tanks. It is with this phenomenon, its elucidation and importance — or insignificance — for the public health, that Dr. Dodgson is mainly occupied.

The magnitude of the apparent failure of the process, viewed in the knowledge of past efficiency, indicated intenvention of a new factor. That no technical irregularity could be traced in the tank operations nor any abnormality detected in the vital functioning of the shellfish pointed to the bacterial flora of the mussel as the disturbing variable.

A study of the contaminating bacilli was therefore undertaken, but ere this was far advanced the anomalous bacterial counts ceased as suddenly as they had begun. Representative material being no longer available, work was continued on general lines, making use of some 18 lactose-fermenting coliform races isolated during the abnormal period: Dr. Newsholme of Birmingham collaborated.

During the abnormal period, barnacles, animals which normally cleanse themselves equally with the mussels which they encrust, were found to pass through the tanks heavily infected with lactose fractors (up to 300,000 per 3 barnacle bodies). Multiplication of the bacilli in the barnacles leading to re-infection of the mussels, multiplication too within the mussels themselves, alone could explain the observed enormous increase of the lactose fractors during transit to (and from) Birmingham and during storage.

Noting positive statements of others regarding multiplication of *B. coli* in tap and river water — especially boiled water — Dr. Dodgson gives his own evidence to show that lactose fractors obtained from mussels returned from Birmingham could multiply in *unheated sterilized tank water* (e.g., 20 per c.c. to 2000 in 5 days and 20,000 in 9 days) *and in mussel shell water* (5-fold increase in 48 hours) and, incidentally, still more rapidly in boiled sea water.

But specially notable was the fact that the bacilli, providing the abnormal counts and showing this ability to multiply in the tank medium, belonged to the Koser-citrate positive groups, failed to grow at 42°C., and were killed at 44°C.; many liquefied gelatin.

When similar tests were made with citrate-negative *B. coli* cultures, viable at 44°C. and derived from polluted mussels, most strains quickly perished, a few persisted without increase and one showed slight increase (200 to 800 per 1 c.c. in 24 hrs.) then decrease. The interesting fact that these *coli* cultures multiplied readily in boiled sea water has no bearing on the issue.

[1]) Journ. du Cons. XII, 1, p. 100, 1937.

To paraphrase freely the lecturer's arguments and conclusions: it would seem probable that throughout the period of abnormal bacteriological results the purification tanks functioned efficiently, but that, on the whole process, there was superimposed a "wave of invasion" by harmless but actively multiplying bacilli, the actual number of which, whatever their ultimate origin, afforded no index whatever of faecal pollution, still less of its degree. (Such data as are available, including some collected at Conway, suggest that typhoid group bacilli do not share this propensity for multiplication in such media as sea water.)

The whole circumstances support the view, long urged by the lecturer, that bacteriological tests for the suitability of shellfish for human consumption should be regarded in proper perspective with topographical, epidemiological, and general considerations; though often the sole criterion on which opinion can be based, these tests are far from infallible. Probably more reliable information may be gained from cultures made at 44°C. than at 37°C.

The concluding paragraphs point out the necessity of efficient purification of shellfish and the danger of pretended purification processes, which threaten the public health and breed undescriminating prejudice.

In this survey of a long experience and record of a special investigation Dr. Dodgson helps to show that original phrase, anecdote and subdued humour have a place in scientific literature.

P. Bruce White.

Current Bibliography.

Prepared by the Editor with the assistance of Miss Thursby-Pelham.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

1) General Oceanography.

1) a Expeditions.

Belloc, G. Rapport général sur la cinquième croisière du navire "Président-Théodore-Tissier". Rev. Trav. Office des Pêches Marit., X, 269—99, Paris, 1937.

Belloc, G. Liste des stations de la cinquième croisière du "Président-Théodore-Tissier". Rev. Trav. Office des Pêches Marit., X, 300—25, Paris, 1937.

Fleming, W. L. S., Stephenson, A., Roberts, B. B. and Bertram, G. C. L. Notes on the Scientific Work of the British Graham Land Expedition, 1934—37. Geogr. Journ., XCI, 508—32, London, 1938.

Mackintosh, N. A. Antarctic Whaling. Polar Record, No. 16, 119—20, Cambridge, 1938.

Mosby, H. Svalbard Waters. Geofys. Publ., XII, 5—85, Oslo, 1938.

Perks, J. P. H. The Deep-Sea Anchorage Equipment. Snellius Exped. 1929—30, I, 72—80, Leiden, 1938.

Pinke, F. The Expeditionary Ship and the Naval Personnel's Share. Snellius Exped. 1929—30, I, 47—71, Leiden, 1938.

van Riel, P. M. Programme of Research and Preparations. Snellius Exped. 1929—30, I, 1—45, Leiden, 1938.

van Riel, P. M. The Voyage in the Netherlands East-Indies. Snellius Exped., 1929—30, I, 85—164, Leiden, 1938.

1) b Institutes.

Anon. The Woods Hole Oceanographic Institution, Report for the Year 1937. Woods Hole, 1938.

Anon. Fifteenth Annual Report for the Year ended December, 1937. Union S. Afr., Off. Journ. Depart. Commerce & Industries, 1, 19—40, Pretoria, 1938.

Cameron, A. T. Annual Report of the Biological Board of Canada for the Year 1937. Ottawa, 1938.

le Danois, E. Rapport sur le fonctionnement de l'Office des Pêches Maritimes pendant l'année 1937. Rev. Trav. Office des Pêches Marit., XI, 9—30, Paris, 1938.

Faouzi, H. Hydrobiology and Fisheries Laboratory, Alexandria, Nature, CXLI, 1107, London, 1938.

Higgins, E. Progress in Biological Inquiries 1937. U.S. Bureau Fish., Admin. Rep. No. 30, Washington, D.C., 1938.

International Council. Procès-Verbaux (Mai — 1938). Cons. Perm. Internat. p. l'Explor. de la Mer. Rapp. et Proc.-Verb., CVII, 1ère Partie, Copenhague, 1938.

International Council. Rapport Administratif (1937—1938). Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 2ème Partie, Copenhague, 1938.

Newcombe, C. L. The 1938 Program of the Chesapeake Biological Laboratory. Collecting Net, XIII, U. S. A., 1938.

Seurat, L. G. XIe Assemblée plénière de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée (Paris, 26—29 Octobre 1931). Stat. d'Aquic. et de Pêche de Castiglione 1936, 1er Fasc., 142, Alger, 1938.

Truitt, R. V. Report of Chesapeake Biological Laboratory. Solomons Island, Md., 1937.

2) Hydrography.

2) a Apparatus and Methods.

Berger, F. Zur Methodik der Gesamtphosphor- und Phosphatbestimmung. Internat. Rev. d. ges. Hydrobiol. usw., XXXVII, 420—24, Leipzig, 1938.

Bremner, R. W. and Thompson, T. G. The Electrical Conductances of Standard Potassium Chloride Solutions throughout the Temperature Range 0 to 25°. Journ. Amer. Chem. Soc., LIX, 2372—378, Easton, Pa., 1937.

Fox, H. M. and Wingfield, C. A. A Portable Apparatus for the Determination of Oxygen Dissolved in a Small Volume of Water. Journ. Exper. Biol., XV, 437—45, London, 1938.

Graham, M. Trial of Methods of Measuring Transparency of Sea Water. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, II, 13—17, Copenhague, 1938.

Hochberg, S. and la Mer, V. K. Microdetermination of Density by the Falling-Drop Method. Indust. and Engin. Chem., IX, 291—92, Easton, Pa., 1937.

Maldura, C. M. Alcune osservazioni sul metodo di Harvey per la determinazione dei nitrati nell'acqua di mare. Boll. Pesca, Piscicolt. e Idrobiol., XIV, 17—30, Roma, 1938.

Meyer, H. Die photometrische Bestimmung des Kupfers im Seewasser. Ann. d. Hydrogr. usw., LXVI, 325—30, Berlin, 1938.

Sauberer, F. und Eckel, O. Zur Methodik der Strahlungsmessungen unter Wasser. Internat. Rev. d. ges. Hydrobiol. usw., XXXVII, 257—89, Leipzig, 1938.

Spilhaus, A. F. A Bathythermograph. Journ. Mar. Res., I, 95—100, New Haven, Conn., 1938.

Stetson, H. C. Current Measurements in the Georges Bank Canyons. Trans. Amer. Geophys. Union, Nation. Res. Council, 216, Washington, D. C., 1937.

Tenani, M. Sulla registraz. della velocità e della direzione delle correnti marine. Un correntometro autoregistratore ad elica. Boll. Com. Geod. e Geof. d. Cons. Naz. delle Ricerche, III, Milano, 1937.

Utterback, C. L. and Higgs, P. M. A Submarine Photometer for Studying the Distribution of Daylight in the Sea. Journ. Opt. Soc. of America, XXVIII, 100—102, U. S. A., 1938.

2) b Surveys.

Anon. Observações oceanográficas. "Albacora", 1937. Trav. Stat. Biol. Marit. de Lisbonne, No. 43, Lisboa, 1938.

Beaugé, L. Note sur les recherches hydrographiques exécutées au cours de la cinquième croisière du "Président-Théodore-Tissier". Rev. Trav. Office des Pêches Marit., X, 327—36, Paris, 1937.

Fleming, W. L. S. The Scientific Work of the International Ice Patrol Board. Polar Record, No. 16, 124—28, Cambridge, 1938.

Kokubo, S. and Tamura, T. Observations on the Plankton and Hydrographic Conditions of Aomori Bay during the Period 1933—1935. Rec. Oceanogr. Works in Japan, X, 1—15, Tokyo, 1938.

Pettersson, H. Nyare oceanografiska undersökningar i Sverige. Ymer, I, Stockholm, 1938.

Phifer, L. D. and Thompson, T. G. Seasonal Variations in the Surface Waters of San Juan Channel during the Five Year Period, January 1931 to December 30, 1935. Sears Found. Journ. Mar. Res., 34—59, New Haven, Conn., 1937—8.

Smith, E. H., Soule, F. M. and Mosby, O. The "Marion" and "General Greene" Expeditions to Davis Strait and Labrador Sea under Direction of the United States Coast Guard 1928—1931—1933—1934—1935. Scientific Results. Part 2. Physical Oceanography. U. S. Treas. Dept., Coast Guard, Bull. No. 19, Washington, 1937.

Thomsen, H. Hydrography of Icelandic Waters. Zool. of Iceland, I, Pt. 4, 1—36, Copenhagen and Reykjavik, 1938.

Thompson, E. F. and Gilson, H. C. Chemical and Physical Investigations. Introduction. John Murray Exped. 1933—34, Brit. Mus. (Nat. Hist.), Scient. Rep., II, 15—81, London, 1938.

Visser, S. W. Oceanographic Results. Part 4. Surface-Observations, Temperature, Salinity, Density. Snellius Exped. 1929—30, II, 1—62, Leiden, 1938.

2) c Chemistry of Sea Water.

von Brand, T. Quantitative Determination of the Nitrogen in the Particulate Matter of the Sea. Journ. du Conseil, XIII, 187—96, Copenhague, 1938.

Clowes, A. J. Phosphate and Silicate in the Southern Ocean. Discovery Rep., XIX, 1—120, Cambridge, 1938.

Frost, N. The Genus *Ceratium* and its use as an Indicator of Hydrographic Conditions in Newfoundland Waters. Res. Bull. No. 5, Dept. of Nat. Resources, St. John's, 1938.

Gabrielsen, E. K. und Steemann Nielsen, E. Kohlensäureassimilation und Lichtqualität bei den marinen Planktondiatomeen (Vorläufige Mitteilung). Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, II, 19—21, Copenhague, 1938.

Goedecke, E. Weitere Ergebnisse der deutschen und dänischen Feuerschiffsbeobachtungen in der Deutschen Bucht während der Jahre 1920 bis 1932. Ann. d. Hydrogr. usw., LXVI, 269—79, Berlin, 1938.

Graham, M. Phytoplankton and the Herring. Part III. Distribution of Phosphate in 1934—1936. Min. Agric. and Fish., Fish. Invest., Ser. II, XVI, No. 3, London, 1938.

Hachey, H. B. The Cold Water Layer of the Scotian Shelf. Science, N. S., LXXXVIII, 307—08, U. S. A., 1938.

Igelsrud, I., Thompson, T. G. and Zwicker, B. M. G. The Boron Content of Sea Water and of Marine Organisms. Univ. of Wash., Publ. in Oceanogr., Suppl. Ser., No. 68, U. S. A., 1938.

Jacobsen, J. P., Buch, K., Schulz, B. and Wattenberg, H. Nomenclature and Units for the Indication of the Content of Constituents of Sea Water. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 3—9, Copenhague, 1938.

Newcombe, C. L. and Horne, W. A. Oxygen-Poor Waters of the Chesapeake Bay. Science, N. S., LXXXVIII, 80—81, U. S. A., 1938.

Seiwell, H. R., and Seiwell, G. E. The sinking of decomposing Plankton in sea water and its relationship to oxygen consumption and phosphorus liberation. Proc. Amer. Phil. Soc., LXXVIII, 465—81, Philadelphia, 1938.

Sverdrup, H. U. On the Explanation of the Oxygen Minima and Maxima in the Oceans. Journ. du Conseil, XIII, 163—72, Copenhague, 1938.

Thomsen, H. Hydrography of Icelandic Waters. Zool. of Iceland, I, Pt. 4, Copenhagen and Reykjavik, 1938.

Webb, D. A. Strontium in Sea Water and its Effect on Calcium Determinations. Nature, CXLII, 751—52, London, 1938.

2) d Physical Properties: General.

Brüne, G. Über die Ausbreitung elektromagnetischer Wellen im Wasser. Leipzig, 1937.

Rouch, J. Leçon d'Ouverture du Cours d'Océanographie Physique. Bull. Inst. Océanogr., No. 749, Monaco, 1938.

Sandström, J. W. Geophysische Untersuchungen im Nordatlantischen Meer. Gerlands Beitr. z. Geophys., LIII, 354—59, Leipzig, 1938.

Seiwell, H. R. Use of Non-Conservative Properties of Sea Water to Physical Oceanographical Problems. Nature, CXLII, 164—65, London, 1938.

Swainson, O. W. Velocity and Ray Paths of Sound Waves in Sea Water (Extract). Hydrogr. Rev., XIV, 93—153, Monaco, 1937.

Thomsen, H. Hydrography of Icelandic Waters. Zool. of Iceland, I, Pt. 4, Copenhagen and Reykjavik, 1938.

2) e Temperature.

Becker, R. Über den jährlichen Temperaturgang auf dem Indischen und Stillen Ozean. Ann. d. Hydrogr. usw., LXVI, 338—40, Berlin, 1938.

Demel, K. Température des eaux côtières polonaises de la Baltique en 1936 et 1937. Bull. Stat. Marit. de Hel, II, 69—74, Warszawa, 1938.

Eggvin, J. The Bottom Temperatures. Fiskeridirek. Skr., Ser. Havunders., Rep. Norwegian Fish. and Mar. Invest., V, No. 6, 51—68, Bergen, 1938.

Frost, N. The Genus *Ceratium* and its Use as an Indicator of Hydrographic Conditions in Newfoundland Waters. Res. Bull. No. 5, Dept. Nat. Resources, St. John's, 1938.

Goedecke, E. Weitere Ergebnisse der deutschen und dänischen Feuerschiffsbeobachtungen in der Deutschen Bucht während der Jahre 1920 bis 1932. Ann. d. Hydrogr. usw., LXVI, 269—79, Berlin, 1938.

Hachey, H. B. The Cold Water Layer of the Scotian Shelf. Science, N. S., LXXXVIII, 207—08, U. S. A., 1938.

Slocum, G. The New Weather Bureau Charts of the Normal Temperature Distribution of the Western North Atlantic Surface Water. Bull. Amer. Meteor. Soc., XII, Easton, Pa., 1937.

Slocum, G. The Normal Temperature Distribution of the Surface Water of the Western North Atlantic Ocean. Monthly Weather Rev., LXVI, 39, Washington, D. C., 1938.

Somma, A. Osservazioni sul colore e sulla temperatura delle acque marine del Golfo di Napoli. Ann., R. Ist. Sup. Navale, VI, Napoli, 1937.

Stephen, A. C. Temperature and the Incidence of Certain Species in Western European Waters in 1932—1934. Journ. Anim. Ecology, VII, 125—29, London, 1938.

Thomsen, H. Hydrography of Icelandic Waters. Zool. of Iceland, I, Pt. 4, Copenhagen and Reykjavik, 1938.

2) f Submarine Illumination.

Clarke, G. L. Light Penetration in the Gulf of Mexico. Journ. Mar. Res., I, 85—94, New Haven, Conn., 1938.

Gabrielsen, E. K. und Steemann Nielsen, E. Kohlensäureassimilation und Lichtqualität bei den marinen Planktondiatomeen. (Vorläufige Mitteilung). Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, II, 19—21, Copenhague, 1938.

Köppen, W. Wie ist der tägliche Gang der Bewölkung auf dem Meere? Ann. d. Hydrogr. usw., LXVI, 340—43, Berlin, 1938.

Pettersson, H. Measurements of the Angular Distribution of Submarine Light. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, II, 7—12, Copenhague, 1938.

Poole, H. H. The Effect of Surface Conditions on the Intensity and Angular Distribution of Submarine Daylight. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, II, 3—6, Copenhague, 1938.

Somma, A. Osservazioni sul colore e sulla temperatura delle acque marine del Golfo di Napoli. Ann., R. Ist. Sup. Navale, VI, Napoli, 1937.

Wattenberg, H. Untersuchung über Durchsichtigkeit und Farbe des Seewassers. II. Kieler Meeresforsch., II, 293—300, Kiel, 1938.

2) g Hydrodynamics.

Hidaka, K. Study of Ocean Waves. Mem. Imp. Mar. Obs., IV, Kobe, 1938.

Koenuma, K. Hydrography of the South-Western Part of the North Pacific and the Kurosio: Characteristic Watermasses which are related to this Region, and their Mixtures, especially the Water of the Kurosio. Mem. Imp. Mar. Obs., IV. Kobe, 1938.

Montgomery, R. B. Fluctuations in Monthly Sea Level on Eastern U. S. Coast, as related to Dynamics of Western North Atlantic Ocean. Journ. Mar. Res., I, 165—85, New Haven, Conn., 1938.

Parr, A. E. On the Validity of the Dynamic Topographic Method for the Determination of Ocean Current Trajectories. Journ. Mar. Res., I, 119—32, New Haven, Conn., 1938.

Parr, A. E. Isopycnic Analysis of Current Flow by Means of Identifying Properties. Journ. Mar. Res., I, 133—54, New Haven, Conn., 1938.

Seiwell, H. R. Eddy Diffusion at Mid-Depths in the Caribbean Sea Region. Journ. du Conseil, XIII, 155—62, Copenhague, 1938.

Stockmann, W. Einige charakteristische Momente der horizontalen Vermischung der Wassermassen des Kaspischen Meeres im System $S = f(t)$. C. R. (Doklady) Acad. Sci. de l'U.R.S.S., 8, 1938.

Sverdrup, H. U. On the Process of Upwelling. Journ. Mar. Res., I, 155—64, New Haven, Conn., 1938.

Thorade, H. The Stratosphere and the Troposphere of the Atlantic Ocean. Translation from the German, Ann. d. Hydrogr. usw., LXV, 174, Berlin, 1937, in Hydrogr. Rev., XIV, 93—153, Monaco, 1937.

Vallaux, C. Recherches du Discovery II sur la dynamique de l'Océan Austral. Bull. Inst. Océanogr., No. 751, Monaco, 1938.

Weinblum, G. Seegangsforschung. Naturwissenschaften, XIII, Berlin, 1938.

Wüst, G. Quantitative Untersuchungen zur Statik und Dynamik des Atlantischen Ozeans. III. Lief. Die dynamischen Werte für die Standardhorizonte an den Beobachtungsstationen. Wiss. Ergebn. Deutsch. Atlant. Exped. a. d. Forsch.- und Vermessungsschiff "Meteor", 1925—1927, VI, Teil II, Berlin und Leipzig, 1938.

2) h Currents and Oceanic Circulation.

Anon. Flaschenpostdrift im südlichen Stillen Ozean. Seewart, VII, 219—20, Hamburg, 1938.

Caballero y Lastres, E. Motives and Considerations concerning the Official Adoption of the Appellation "Peruvian Current". Hydrogr. Rev., XIV, 61—64, Monaco, 1937.

Carruthers, J. N. Continuous Current Measuring from Lightvessels. Review of Progress, with Results for a third Winter — 1937/38. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 16—20, Copenhague, 1938.

Carruthers, J. N. The Horsey Floods of February, 1938. Current and Wind at the Time as observed aboard Certain Lightvessels. Meteor. Mag., LXXIII, 86—93, London, 1938.

Ciocârdel, R. Circulation générale des eaux de la Mer Noire. Bul. Soc. Reg. Române de Géogr., LVI, Bucuresti, 1937.

Demel, K. Szkice Baltyckie. Kosmosu, LXIII, 107—72, Lwow, 1938.

Goedecke, E. Weitere Ergebnisse der deutschen und dänischen Feuerschiffsbeobachtungen in der Deutschen Bucht während der Jahre 1920 bis 1932. Ann. d. Hydrogr. usw., LXVI, 269—79, Berlin, 1938.

Marmer, H. A. The Kuroshio or Japan Current (Extract). Hydrogr. Rev., XIV, 86—88, Monaco, 1937.

Römer, E. Starker westlicher Strom im südlichen Skagerrak. Seewart, VII, 184—86, Hamburg, 1938.

Thomsen, H. Hydrography of Icelandic Waters. Zool. of Iceland, I, Pt. 4, Copenhagen and Reykjavik, 1938.

Thorade, H. Kann eine Meeresströmung sich als Freistrahl entwickeln? Ann. d. Hydrogr. usw., LXVI, 308—10, Berlin, 1938.

2) i Tides and Sea Level.

Anon. The Admiralty Tide Tables. Part I. Tidal Predictions for the Year 1939. Section B, Foreign Waters. London, 1938.

Dietrich, G. Die Lage der Meeresoberfläche im Druckfeld von Ozean und Atmosphäre. Berlin, 1938.

Evans, O. F. The Undertow. Science, N. S., LXXXVIII, 279—81, U. S. A., 1938.

Goldsborough, G. R. Tides of the British Seas. Nature, CXLI, 1066—67, London, 1938.

LaFond, E. C. Relationship between Mean Sea Level and Sand Movements. Science, N. S., LXXXVIII, 112—13, U. S. A., 1938.

Montgomery, R. B. Fluctuations in monthly Sea Level on Eastern U. S. Coast as related to Dynamics of Western North Atlantic Ocean. Journ. Mar. Res., I, 165—85, New Haven, Conn., 1938.

Takegami, T. A Study of the Effect of a Travelling Atmospheric Disturbance upon the Sea-Surface. Mem. Coll. Sci., Kyoto Imp. Univ., Ser. A, XXI, 55—74, Kyoto, 1938.

Tenani, M. Stato attuale delle osservazioni mareografiche in Italia. Boll. Com. Geod. e Geof. d. Cons. Naz. delle Ricerche, III, Milano, 1937.

Tuboi, I. On the Harmonic Analysis of Tide. Journ. Oceanogr. Imp. Mar. Observ., XI, 205—18, Kobe, 1938.

2) j Geography, Geology and Bottom Deposits.

Anon. Der Internationale Geographenkongress in Amsterdam, 18—28 Juli 1938. Petermanns Geogr. Mitt., LXXXIV, 269—78, Gotha, 1938.

Boschma, H. and Kuemen, P. H. Investigations on Shore. Snellius Exped. 1929—30, I, 170—77, Leiden, 1938.

le Grand, Y. Quelques particularités des rides de sable. Bull. Soc. d'Océanogr. de France, XVIII, 1721—26, Paris, 1938.

LaFond, E. C. Relationship between Mean Sea Level and Sand Movements. Science, N. S., LXXXVIII, 112—13, U. S. A., 1938.

Larmor, J. Intense Radioactivity of the Superficial Ocean Floor. Nature, CXLII, 37, London, 1938.

Lewis, W. V. The Evolution of Shore Line Curves. Proc. Geol. Assoc., XLIX, 107—27, London, 1938.

Obara, N. Studies of the Bottom Material of Simoda Bay, Idu Peninsula. Rec. Oceanogr. Works in Japan, X, 43—58, Tokyo, 1938.

P. V. Soundings in the North Atlantic Ocean. Hydrogr. Rev., XIV, 59, Monaco, 1937.

Stetson, H. C. The Sediments of the Continental Shelf off the Eastern Coast of the United States. Pap. in Phys. Oceanogr. and Meteor., V, No. 4, Woods Hole, Mass., 1938.

Stocks, T. Morphologie des Atlantischen Ozeans. Grundkarte der Ozeanischen Lotungen 1 : 5 Millionen. Berlin und Leipzig, 1937.

Stocks, T. Morphologie des Atlantischen Ozeans. 2 Lief. Statistik der Tiefenstufen des Atlantischen Ozeans. Wiss. Ergebn. Deutsch. Atlant. Exped. a. d. Forsch- und Vermessungsschiff "Meteor", 1925—1927, III, 35—151, Berlin, 1938.

Waksman, S. A. On the Oxidation of Organic Matter in Marine Sediments by Bacteria. Journ. Mar. Res., I, 101—18, New Haven, Conn., 1938.

2) k Ice.

Blüthgen, J. Die Eisverhältnisse des Finnischen und Rigaischen Meerbusens. Deutsch. Seewarte, LVIII, Nr. 3, Hamburg, 1938.

Oellrich, H. Die Eisverhältnisse an den deutschen Küsten, von Memel und der Freien Stadt Danzig im Winter 1937/38. Seewart, VII, 202—06, Hamburg, 1938.

Oellrich, H. Die Eisverhältnisse an den deutschen Küsten einschliesslich Danzig und Memel im Winter 1937/38. Ann. d. Hydrogr. usw., LXVI, 349—52, Berlin, 1938.

Saem, B. Isrek vid Graenland og Island árid 1937. Aegir, XXXI, 170—73, Reykjavik, 1938.

Thomsen, H. The State of the Ice in the Arctic Seas 1937. Publ. Danske Meteor. Inst. Aarbøger, København, 1938.

2) l Meteorology.

Appleton, E. V. and Weekes, K. Tides in the Upper Atmosphere. Nature, CXLII, 71, London, 1938.

Carruthers, J. N. Fluctuations in the Herrings of the East Anglian Autumn Fishery, the Yield of the Ostend Spent Herring Fishery, and the Haddock of the North Sea — in the Light of relevant Wind Conditions. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 10—15, Copenhague, 1938.

József, S.-K. Verteilung der Luftfeuchtigkeit auf der Erde. Ann. d. Hydrogr. usw., LXVI, 373—78, Berlin, 1938.

3) Plankton.

3) a Apparatus and Methods.

Hardy, A. C. Estimating Numbers without Counting. Nature, CXLII, 255—56, London, 1938.

Hendey, N. I. An Efficient Technique for Cleaning Diatoms. Journ. Roy. Microscop. Soc., 3rd Ser., LVIII, 49—52, London, 1938.

Hentschel, E. Über die Herstellung von Planktonkarten des Nordatlantischen Ozeans. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 69—71, Copenhague, 1938.

Marr, J. W. S. On the Operation of Large Plankton Nets. Discovery Rep., XVIII, 105—20, Cambridge, 1938.

Steemann Nielsen, E. Über die Anwendung von Netzfängen bei quantitativen Phytoplanktonuntersuchungen. Journ. du Conseil, XIII, 197—205, Copenhague, 1938.

3) b General.

Aikawa, H. On the Quantitative Analysis of the Plankton Association in the Adjacent Seas of Japan. Journ. Imp. Fish. Exper. Stat., No. 9, 86—100, Tokyo, 1938. (In Japanese, English résumé).

Bernard, F. Cycle annuel du nanoplancton à Monaco et à Banyuls: I. Étude quantitative. Ann. Inst. Océanogr. Monaco, N. S., XVII, 349—406, Paris, 1938.

Bursa, A. Notice about some Interesting Plankton Species till yet unknown from the Gulf of Danzig. Bull. Stat. Marit. de Hel, II, 63—68, Warszawa, 1938.

Kokuba, S. and Tamura, T. Observations on the Plankton and Hydrographic Conditions of Aomori Bay during the Period 1933—1935. Rec. Oceanogr. Works in Japan, X, 1—15, Tokyo, 1938.

Wells, A. L. Some Notes on the Plankton of the Thames Estuary. Journ. Anim. Ecol., VII, 105—24, London, 1938.

3) c Phytoplankton.

Allen, W. E. "Red Water" along the West Coast of the United States in 1938. Science, N. S., LXXXVIII, 55—56, U. S. A., 1938.

Bernard, F. Résultats de l'examen préliminaire des prises d'eau faites à bord du "Président-Théodore-Tissier". Rev. Trav. Office Pêches Marit., X, 337—38, Paris, 1937.

Conrad, W. Notes Protistologiques. III. Chrysomonadines intéressantes du nannoplankton saumâtre. Bull. Mus. Roy. d'Hist. Nat. de Belgique, XIV, No. 29, Bruxelles, 1938.

Frost, N. The Genus *Ceratium* and its Use as an Indicator of Hydrographic Conditions. Res. Bull. No. 5, Dept. of Nat. Resources, St. John's, 1938.

Gabrielsen, E. K. und Steemann Nielsen, E. Kohlensäureassimilation und Lichtqualität bei den marinen Planktondiatomeen. (Vorläufige Mitteilung). Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, II, 19—21, Copenhague, 1938.

Graham, M. Phytoplankton and the Herring. Part III. Distribution of Phosphate in 1934—1936. Min. Agric. and Fish., Fish. Invest., Ser. II, Vol. XVI, No. 3, London, 1938.

Steemann Nielsen, E. Über die Anwendung von Netzfängen bei quantitativen Phytoplanktonuntersuchungen. Journ. du Conseil, XIII, 197—205, Copenhague, 1938.

3) d Zooplankton.

Gurney, R. Larvae of Decapod Crustacea. Part V. Nephropsidea and Thalassinidea. Discovery Rep., XV, 291—344, Cambridge, 1938.

Gurney, R. The Larvae of the Decapod Crustacea. Palaemonidae and Alpheidae. Great Barrier Reef Exped. 1928—29, Brit. Mus. (Nat. Hist.), Scient. Rep., VI, 1—60, London, 1938.

Hertling, H. Über eine auf Juist gestrandete *Sthenoteuthis caroli* (Furtado). Helgol. Wiss. Meeresunters., I, 93—111, Kiel, 1938.

Kiefer, F. Beiträge zur Copepodenkunde. XVIII. Zool. Anz., CXXII, 249—54, Leipzig, 1938.

Mankowski, W. *Oithona similis* Claus an element of West Baltic Zooplankton in the Gulf of Danzig. Bull. Stat. Marit. de Hel, II, 18—24, Warszawa, 1938.

Mankowski, W. Notice of the Zooplankton in the Gulf of Danzig. Bull. Stat. Marit. de Hel, II, 54—56, Warszawa, 1938.

Mielck, W. und Stier, A. Der Formenkreis *Caementella loricata* Borgert und seine Beziehungen zu *Protocystis*. Helgol. Wiss. Meeresunters., I, 141—61, Kiel, 1938.

Monard, A. Les Harpacticoides marins de la région de Salammbô. Stat. Oceanogr. de Salammbô, Bull. No. 34, Tunis, 1935.

Needler, A. B. The Larval Development of *Pandalus stenolepis*. Journ. Fish. Res. Board Canada, IV, 136—40, Toronto, 1938.

Russell, F. S. Chaetognatha I. 1938. Zooplankton Sheets. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie (Enclosure), Copenhague, 1938.

Stephen, A. C. Temperature and the Incidence of Certain Species in Western European Waters in 1932—1934. Journ. Anim. Ecol., VII, 125—29, London, 1938.

Stubbings, H. G. Phyllirhoidae. John Murray Exped. 1933—34, Brit. Mus. (Nat. Hist.), Scient. Rep., V, 1—4, London, 1938.

Tattersall, W. M. A Note on the Trachelifer Larva of *Jaxea nocturna* (Chiereghin) and its Metamorphosis. Ann. and Mag. Nat. Hist., 11th Ser., I, 625—31, London, 1938.

Weill, R. Une méduse tropicale dite Indopacifique, *Gonionemus suvaensis* Ag. et Mayer, dans l'Océan Atlantique (Iles Bermudes). Bull. Soc. Zool. de France, LXIII, 33—41, 1938.

3) e Physiology and Behaviour.

Kikuchi, K. Studies on the Vertical Distribution of the Plankton Crustacea. II. The Reversal of Phototropic and Geotropic Signs of the Plankton Crustacea with Reference to the Vertical Movement. Rec. Oceanogr. Works in Japan, X, 17—41, Tokyo, 1938.

4) Organic Production.

4) b Bacteria.

Kimata, M. Studies of the Sulphate Reducing Bacteria, Isolated from the Black Bottom-mud of Brackish Waters. I. Bull. Japan. Soc. Sci. Fish., VII, 139—43, Tokyo, 1938.

Waksman, S. A. On the Oxidation of Organic Matter in Marine Sediments by Bacteria. Journ. Mar. Res., I, 101—18, New Haven, Conn., 1938.

5) Bottom Fauna and Flora.

5) a Apparatus and Methods.

Thamdrup, H. M. Der van Veen-Bodengreifer. Vergleichsversuche über die Leistungsfähigkeit des van Veen- und des Petersen-Bodengreifers. Journ. du Conseil, XIII, 206—12, Copenhague, 1938.

5) b Systematics and Development.

Adam, W. Sur quelques Céphalopodes Octopodes des Iles Andamans. Bull. Mus. Roy. d'Hist. Nat. de Belgique, XIV, No. 7, Bruxelles, 1938.

Brown, R. S. The Anatomy of the Polychaete *Ophelia cluthensis* McGuire 1935. Proc. Roy. Soc. Edinburgh, LVIII, 135—60, Edinburgh, 1938.

Calman, W. T. Pycnogonida. John Murray Exped. 1933—34, Brit. Mus. (Nat. Hist.), Scient. Rep., V, 147—66, London, 1938.

Calvez, J. le. Recherches sur les Foraminifères. I. Développement et reproduction. Arch. Zool. Expér. et Gén., LXXX, 163—333, Paris, 1938.

Carlgren, O. Ceriantharia and Zoantharia. Great Barrier Reef Exped. 1928—29, Scient. Rep., V, 177—207, London, 1938.

Clark, H. L. Echinoderms from Australia. An Account of Collections made in 1929 and 1932. Mem. Mus. Comp. Zool. at Harvard Coll., LV, Cambridge, U. S. A., 1938.

Dawydoff, C. Les Coeloplanides indochinoises. Arch. Zool. Expér. et Gén., LXXX, 125—62, Paris, 1938.

Divers Auteurs. Mémoires sur les Crustacés et Pycnogonides des croisières du Prince Albert 1er de Monaco. Résult. Camp. Sci. Monaco, XCVII, Monaco, 1938.

Eales, N. B. A Systematic and Anatomical Account of the Opisthobranchia. John Murray Exped. 1933—34, Brit. Mus. (Nat. Hist.), Scient. Rep. V, 9—122, London, 1938.

Feliksiak, S. Radula von *Hydrobia ulvae* Pennant, aus der Litorina-Zeit. Zool. Anz., CXXII, 186—89, Leipzig, 1938.

Friedrich, H. *Atyponemertes korscheltii*, n. gen. n. spec., ein abweichender Hoplonemertinentypus aus der Nordsee. Zool. Anz., CXXIV, 22—30, Leipzig, 1938.

Harant, H. et Vernières, P. Faune de France. 33. Tuniciers. Fasc. 2. Appendiculaires et Thaliáces. Office Cent. de Faunistique, Paris, 1938.

Hartman, O. Brackish and Fresh-Water Nereidae from the Northeast Pacific, with the Description of a New Species from Central California. Univ. of Calif. Publ. in Zool., XLIII, 79—82, Berkeley, Calif., 1938.

Hartman, O. Descriptions of New Species and New Generic Records of Polychaetous Annelids from California of the Families Glyceridae, Eunicidae, Stauronereidae, and Opheliidae. Univ. of Calif. Publ. in Zool., XLIII, 93—112, Berkeley, Calif., 1938.

Heding, S. G. *Cucumaria tetracentriophora*, sp. n., a New Dendrochirote Holothurian from South Africa. Ann. and Mag. Nat. Hist., 11th Ser., I, 631—34, London, 1938.

Helmcke, J.-G. Die systematische Stellung der Discinidae (Brachiopoda). Zool. Anz., CXXIII, 113—22, Leipzig, 1938.

van der Horst, C. J. *Balanophyllias* from the Cape of Good Hope. Ann. and Mag. Nat. Hist., 11th Ser., II, 139—45, London, 1938.

Joubin, L. Cours d'Océanographie biologique. Les Ophiures. Bull. Soc. d'Océanogr. de France, XVIII, 1739—40, Paris, 1938.

Kiefer, F. Beiträge zur Copepodenkunde, XVIII. Zool. Anz., CXXII, 249—54, Leipzig, 1938.

Klie, W. Zwei neue Ostracoden aus der Ostsee. Kieler Meeresforsch., II, 345—51, Kiel, 1938.

Kunz, H. Die sandbewohnenden Copepoden von Helgoland. I. Teil. Kieler Meeresforsch., II, 223—54, Kiel, 1938.

Lacroix, E. Sur une texture méconnue de la coquille de diverses Massilines des mers tropicales. Bull. Inst. Océanogr., No. 750, Monaco, 1938.

Lacroix, E. Revision du genre *Massilina*. Bull. Inst. Océanogr., No. 754, Monaco, 1938.

Lamy, E. Huîtres de l'Indochine (2e Note). Bull. Mus. Nation. d'Hist. Nat., 2e Sér., X, 287—91, Paris, 1938.

Lamy, E. et Fischer-Piette, E. Notes sur les espèces Lamarckiennes de *Crisia* (Moll. Lamellibr.). Bull. Mus. Nation. d'Hist. Nat., 2e Sér., X, 82—85, Paris, 1938.

Lamy, E. et Fischer-Piette, E. Notes sur les espèces Lamarckiennes d'*Anomalocardia* (Moll. Lamellibr.). Bull. Mus. Nation. d'Hist. Nat., 2e Sér., X, 173—75, Paris, 1938.

Lamy, E. et Fischer-Piette, E. Notes sur les espèces Lamarckiennes d'*Antigona* (Moll. Lamellibr.). Bull. Mus. Nation. d'Hist. Nat., 2e Sér., X, 292—97, Paris, 1938.

Lamy, E. et Fischer-Piette, E. Notes sur les espèces Lamarckiennes de *Circe* (Moll. Lamellibr.). Bull. Mus. Nation. d'Hist. Nat., 2e Sér., IX, 384—86, Paris, 1938.

Lutze, J. Über Systematik, Entwicklung und Ökologie von *Callianassa*. Helgol. Wiss. Meeresunters., I, 162—99, Helgoland, 1938.

Macan, T. T. Asteroidea. John Murray Exped. 1933—34, Brit. Mus. (Nat. Hist.), Scient. Rep., IV, 324—435, London, 1938.

Meixner, J. Turbellaria (Strudelwürmer). I. Tierwelt d. Nord- u. Ostsee (Grimpe u. Wagler), XXXIII, iv. b, Leipzig, 1938.

Monro, C. C. A. On a Small Collection of Polychaeta from Uruguay. Ann. and Mag. Nat. Hist., 11th Ser., II, 311—14, London, 1938.

Moritz, C. E. The Anatomy of the Gasteropod (*Crepidula adunca* Sowerby). Univ. of Calif., Publ. in Zool., XLIII, 83—92, Berkeley, Calif., 1938.

Newcombe, C. L., Phillips, N. E., and Gould, S. A. Growth Indices of *Littorina irrorata*. Parts I and II. Biol. Gen., XIII, 465—81, Wien und Leipzig, 1937.

Newcombe, C. L., Thompson, S. J. and Kessler, H. Variations in Growth Indices of *Venus mercenaria* L. from widely separated Environments of the Atlantic Coast. Canadian Journ. Res., Sec. D, XVI, 1—5, Ottawa, 1938.

Quayle, D. B. *Paphia bifurcata*, a New Molluscan Species from Ladysmith Harbour, B. C. Journ. Fish. Res. Board Canada, IV, 53—54, Toronto, 1938.

Ramadan, M. M. Crustacea: Penaeidae. John Murray Exped. 1933—34, Brit. Mus. (Nat. Hist.), Scient. Rep., V, 35—76, London, 1938.

Ramadan, M. M. The Astacura and Palinura. John Murray Exped. 1933—34, Brit. Mus. (Nat. Hist.), Scient. Rep., V, 123—45, London, 1938.

Remane, A. Ergänzende Mitteilungen über *Monobryozoon ambulans* Remane. Kieler Meeresforsch., II, 356—58, Kiel, 1938.

Rhumbler, L. Foraminiferen aus dem Meeressand von Helgoland. Kieler Meeresforsch., II, 157—222, Kiel, 1938.

Schmidt, G. A. et Jankovskaia, L. A. Biologie de la reproduction de *Lineus gesserensis ruber* de Roscoff et du Golfe de Kola. Archiv. Zool. Expér. et Gén., LXXX, 487—513, Paris, 1938.

Schulz, E. Beiträge zur Kenntnis mariner Suctorien. VIII. Kieler Meeresforsch., II, 354—55, Kiel, 1938.

Stiasny, G. Catalogue raisonné des Alcyonidés, Gorgonidés, Zoanthidés et Pennatulidés des collections H. Michelin (A. Alcyonidés). Bull. Mus. Nation. d'Hist. Nat., 2e Sér., IX, 391—97, Paris, 1938.

Stiasny, G. Catalogue raisonné des Alcyonidés, Gorgonidés, Zoanthidés et Pennatulidés de la collection H. Michelin (B. Gorgonidés). Bull. Mus. Nation. d'Hist. Nat., 2e Sér., X, 93—108, Paris, 1938.

Tattersall, W. M. Discovery of *Coeloplana* sp. at Krusadi Island Marine Biological Station, Madras. Nature, CXLII, 482, London, 1938.

5) c Distribution and Ecology.

Adam, W. et Leloup, E. Prosobranchia et Opisthobranchia. Résult. Sci. du Voyage aux Indes Orient. Néerland., II, Fasc. 19, Bruxelles, 1938.

Calman, W. T. Pycnogonida. John Murray Exped. 1933—34, Brit. Mus. (Nat. Hist.), Scient. Rep., V, 147—66, London, 1938.

Engel, H. Astéries et Ophiures. Résult. Sci. du Voyage aux Indes Orient. Néerland., III, Fasc. 18, Bruxelles, 1938.

Engel, H. Astéries du voyage aux Indes Orientales Néerlandaises (1932) de LL. AA. RR. le Prince et la Princesse Léopold de Belgique. Bull. Mus. Roy. d'Hist. Nat. de Belgique, XIV, No. 18, Bruxelles, 1938.

Fraser, J. H. The Fauna of Fixed and Floating Structures in the Mersey Estuary and Liverpool Bay. Proc. and Trans. Liverpool Biol. Soc., LI, 1—21, Liverpool, 1938.

Hatton, H. Essais de bionomie explicative sur quelques espèces intercotidales d'algues et d'animaux. Ann. Inst. Océanogr. Monaco, N. S., XVII, Paris, 1938.

Holly, M. Polychaeten aus der Nordsee. Bull. Mus. Roy. d'Hist. Nat. de Belgique, XIV, No. 12, Bruxelles, 1938.

Kolosváry, G. v. Faunistische Neuigkeiten meiner zoologischen Adriareisen 1937—38. Zool. Anz., CXXIII, 106—09, Leipzig, 1938.

Kramp, P. L. Marine Hydrozoa; Hydroida. Zool. of Iceland, II, Pt. 5a, Copenhagen and Reykjavik, 1938.

Leloup, E. Contributions à l'étude de la faune belge. IX. La propagation du crabe chinois en Belgique pendant l'année 1937. Bull. Mus. Roy. d'Hist. Nat. de Belgique, XIV, No. 14, Bruxelles, 1938.

Leloup, E. Quelques Hydraires des côtes orientale et occidentale des Etats-Unis. Bull. Mus. Roy. d'Hist. Nat. de Belgique, XIV, No. 3, Bruxelles, 1938.

Macan, T. T. Asteroidea. John Murray Exped. 1933—34. Brit. Mus. (Nat. Hist.), Scient. Rep., IV, 324—435, London, 1938.

Mulicki, Z. Note of the Quantitative Distribution of the Bottom Fauna near the Polish Coast of the Baltic. Bull. Stat. Marit. de Hel, II, 75—99, Warszawa, 1938.

Nicol, E. A. T. The Brackish-water Lochs of Orkney. Proc. Roy. Soc. Edinburgh, LVIII, 181—91, Edinburgh, 1938.

Ramadan, M. The Astacura and Palinura. John Murray Exped. 1933—34, Brit. Mus. (Nat. Hist.), Scient. Rep., V, 123—45, London, 1938.

Stephen, A. C. Production of Large Broods in Certain Marine Lamellibranchs with a Possible Relation to Weather Conditions. Journ. Anim. Ecology, VII, 130—43, London, 1938.

Stephensen, K. Euphausiacea, Mysidacea, Cumacea and Nebaliacea. Zool. of Iceland, III, Pt. 29, Copenhagen and Reykjavik, 1938.

Stubbings, H. G. Pteropoda. John Murray Exped. 1933—34, Brit. Mus. (Nat. Hist.), Scient. Rep., V, 15—33, London, 1938.

Vilela, H. Colecçao oceanográfica de D. Carlos I. Crustáceos Decápodes Estomatópodes. Trav. Stat. Biol. Marit. de Lisbonne, No. 40, Lisboa, 1936.

5) d Physiology and Behaviour.

Atkins, D. On the Ciliary Mechanisms and Interrelationships of Lamellibranchs. V. Note on the Gills of *Amussium pleuronectes*. VI. The Pattern of the Lateral Ciliated Cells of the Gill Filaments of the Lamellibranchia. VII. Latero-frontal Cilia of the Gill Filaments and their Phylogenetic Value. Quart. Journ. Microscop. Sci., N. S., LXXX, 321—436, London, 1938.

Dakin, W. J. The Habits and Life-History of a Penaeid Prawn (*Penaeus plebejus* Hesse). Proc. Zool. Soc. London, CVIII, Ser. A, 163—83, London, 1938.

Hotovy, R. Die Abhängigkeit des Sauerstoffverbrauches von der Temperatur und Körpergrösse bei *Triops cancriformis* B. Zool. Anz., CXXII, 198—208, Leipzig, 1938.

Igelsrud, I., Thompson, T. G. and Zwicker, B. M. G. The Boron Content of Sea Water and of Marine Organisms. Univ. of Wash., Publ. in Oceanogr., Suppl. Ser., No. 68, U. S. A., 1938.

Kitching, J. A. Contractile vacuoles. Biol. Rev. Cambridge Phil. Soc., XIII, 403—44, Cambridge, 1938.

Marinescu, T. Notes sur le spectre ultraviolet de la pourpre. Bull Inst. Océanogr., No. 753, Monaco, 1938.

Needham, J. Contributions of chemical physiology to the problem of reversibility in evolution. Biol. Rev. Cambridge Phil. Soc., XIII, 225—51, Cambridge, 1938.

van Oordt, J. G. The Spermatheca of *Loligo vulgaris*. I. Structure of the Spermatheca and function of its Unicellular Glands. Quart. Journ. Microscop. Sci., LXXX, 593—99, London, 1938.

Portier, P. Recherches de Physiologie comparée faites à bord de la "Princesse Alice". Résult. Camp. Sci. Monaco, XCVIII, Monaco, 1938.

Pumphrey, R. J. The Double Innervation of Muscles in the Clam. (*Mya arenaria*). Journ. Exper. Biol., XV, 500—05, Cambridge, 1938.

Pumphrey, R. J. and Young, J. Z. The Rates of Conduction of Nerve Fibres of Various Diameters in Cephalopods. Journ. Exper. Biol., XV, 453—66, Cambridge, 1938.

Rinke, H. Über die chemische Zusammensetzung einiger Bodentiere der Nord- und Ostsee und ihre Heizwertbestimmung. Helgol. Wiss. Meeresunters., I, 112—40, Helgoland, 1938.

Ubisch, L. v. Eine vergleichende Studie über die Organisation des Keimes von Seeigeln, Amphibien und Aszidien. Biol. Zentralbl., LVIII, 370—85, Leipzig, 1938.

Welsh, J. H. Occurrence of Acetylcholine in Nervous Tissue of Crustaceans and its Effect on the Crab Heart. Nature, CXLII, 151, London, 1938.

5) e Parasitic Forms.

Adam, W. Sur une larve de cestode de *Mesoplodon bidens* (Sowerby). Bull. Mus. Roy. d'Hist. Nat. de Belgique, XIV, No. 15, Bruxelles, 1938.

Adam, W. Notes sur les Céphalopodes. IX. Sur la présence d'une larve de cestode (*Tetrarhynchidae*) dans la cavité palléale d'un Octopus des Iles Andamans. Bull. Mus. Roy. d'Hist. Nat. de Belgique, XIV, No. 35, Bruxelles, 1938.

Monod, T. Sur un Copépode parasite de *Ziphius* cf. *cavirostris* (?) G. Cuvier 1823. Stat. d'Aquic. et de Pêche de Castiglione, 1936, 1er Fasc., 211, Alger, 1938.

Monod, T. *Conchoderma auritum* (L. 1767) Olfers 1814 sur un *Ziphius* cf. *cavirostris* (?) G. Cuvier 1823. Stat. d'Aquic, et de Pêche de Castiglione, 1936, 1er Fasc., 205, Alger, 1938.

Noble, E. R. The Life Cycle of *Zygosoma globosum* sp. nov. a Gregarine Parasite of *Urechis caupo*. Univ. of Calif. Publ. in Zool., XLIII, 41—66, Berkeley, Calif., 1938.

Raabe, Z. Sur quelques espèces nouvelles d'infusoires parasites de Comatules. Bull. Inst. Océanogr., No. 756, Monaco, 1938.

Townsend, L. D. A New Species of the Genus *Lepeophtheirus* from the North Pacific. Ann. and Mag. Nat. Hist., 11th Ser., I, 599—604, London, 1938.

Tseng-Jui, T. Über einige in Polychaetenröhren und Muscheln gefundene Dekapoden an der Küste von Schantung. Zool. Anz., CXXII, 177—86, Leipzig, 1938.

5) f Marine Plants.

Bursa, A. *Chlorochytrium Cohni* Wright in the Coastal Waters of Danzig Gulf. Bull. Stat. Marit. de Hel, II, 40—43, Warszawa, 1938.

Feldmann, J. et Fremy, P. Matériaux pour la Flore Algologique Marine de la Tunisie. II. Contribution à l'étude biologique et systématique de la "Muffa". Stat. Océanogr. de Salammbô, Notes No. 29, Tunis, 1935.

Hatton, H. Essais de bionomie explicative sur quelques espèces intercotidales d'algues et d'animaux. Ann. Inst. Océanogr. Monaco, N. S., XVII, 242—344, Paris, 1938.

Igelsrud, I., Thompson, T. G. and Zwicker, B. M. G. The Boron Content of Sea Water and of Marine Organisms. Univ. of Wash., Publ. in Oceanogr., Suppl. Ser., No. 68, U. S. A., 1938.

Jacques, A. G. and Osterhout, W. J. V. The Accumulation of Electrolytes. X. Accumulation of Iodine by *Halicystis* and *Valonia*. Journ. Gen. Physiol., XXI, 687—93, Baltimore, 1938.

Jao, C.-C. New Marine Algae from Washington. Pap. Michigan Acad. Sci., Arts and Letters, XXII, 99—116, New York, 1937.

Lemoine, P. Les Nullipores (Algues calcaires) de la collection Michelin. I. Espèces actuelles. Bull. Mus. Nation. d'Hist. Nat., 2e Sér., X, 305—07, Paris, 1938.

Lunde, G. og Lunde, S. Undersøkelser over forekomsten av carrageen. Fiskeridirek. Skr., Ser. Havunders. Rep. Norwegian Fish. and Mar. Invest., V, No. 5, Bergen, 1938.

Montfort, C. Funktionstypen des Assimilationsapparates und das Problem der gelben Blattfarbstoffe. I. Aufdeckung und vergleichende Analyse der Carotinoidwirkungen. Kieler Meeresforsch., II, 301—44, Kiel, 1938.

Norris, E. R., Simeon, M. K. and Williams, H. B. The Vitamin B and Vitamin C Content of Marine Algae. Journ. Nutrition, XIII, 425—33, Baltimore, 1937.

Wetzel, W. Die Schalenzerstörung durch Mikroorganismen, Erscheinungsform, Verbreitung und geologische Bedeutung in Gegenwart und Vergangenheit. Kieler Meeresforsch., II, 255—71, Kiel, 1938.

Wirth, H. E. and Rigg, G. B. The Acidity of the Juice of Desmarestia. Amer. Journ. Botany, XXIV, 68—70, U. S. A., 1937.

6) Fish.

6) a Systematics, Morphology and Development.

Aikawa, H. and Kato, M. Age Determination of Fish. I and II. Bull. Japan. Soc. Sci. Fish., VII, 79—95, Tokyo, 1938. (In Japanese, English résumé).

Belloc, G. Sur la capture dans le bassin d'Arcachon d'un Squale nouveau (*Euprotomicrus Sarmenti* Noronha). Bull. Mus. Nation. d'Hist. Nat., 2e Sér., IX, 370—72, Paris, 1938.

Belloc, G. Sur un poisson comestible nouveau de la côte occidentale d'Afrique: *Paracubiceps Ledanoisi*. Rev. Trav. Office Pêches Marit., X, 353—56, Paris, 1937.

Berridge, W. S. All about Fish and Other Denizens of the Seas and Rivers. London, 1938.

Chapman, W. M. and Townsend, L. D. The Osteology of *Zaprora silenus* Jordan, with Notes on its Distribution and Early Life-History. Ann. and Mag. Nat. Hist., 11th Ser., II, 89—117, London, 1938.

Colefax, A. N. A Preliminary Investigation of the Natural History of the Tiger Flathead (*Neoplatycephalus macrodon*) on the South-eastern Australian Coast. ii. Feeding Habits; Breeding Habits. Proc. Linn. Soc. N. S. Wales, LXIII, 55—64, Sydney, 1938.

Fage, L. et Veillet, A. Sur quelques Problèmes Biologiques liés à l'Étude de la Croissance des Poissons. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 45—48, Copenhague, 1938.

Fowler, H. W. Descriptions of New Fishes obtained by the United States Bureau of Fisheries Steamer "Albatross", chiefly in Philippine Seas and Adjacent Waters. Proc. U. S. Nation. Mus., LXXXV, 31—135, Washington, 1938.

Fraser-Brunner, A. A New Fish of the Genus *Selenotoca*. Ann. and Mag. Nat. Hist., 11th Ser., II, 76—80, London, 1938.

le Gall, J. La biométrie dans ses applications à l'industrie des pêches maritimes. Rev. Trav. Office des Pêches Marit., XI, 45—51, Paris, 1938.

Hjort, J. Studies of Growth in the North-Eastern Area. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 1—8, Copenhague, 1938.

Jensen, A. J. C. Factors determining the Apparent and the Real Growth. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 109—14, Copenhague, 1938.

Johnston, M. Some Methods of Preparing Teleost Fish Otoliths for Examination. Journ. Roy. Microscop. Soc., Ser. III, LVIII, 112—19, London, 1938.

Matsubara, K. Studies on the Deep-Sea Fishes of Japan. IX. Description of a New Gadid Fish. Bull. Japan. Soc. Sci. Fish., VII, 61—62, Tokyo, 1938.

Matsubara, K. Studies on the Deep-Sea Fishes of Japan. X. On a New Fish, *Notacanthus fascidens* belonging to Heteromi with Special Reference to its Variations. Bull. Japan. Soc. Sci. Fish., VII, 131—36, Tokyo, 1938.

Norman, J. R. Coast Fishes. Part III. The Antarctic Zone. Discovery Rep., XVIII, 1—105, Cambridge, 1938.

Ottestad, P. Notes on Statistical Methods of Growth Studies. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 9—12, Copenhague, 1938.

Owen, B. B. A Simple Teleost Kidney in the Genus *Cyclothon*. Biol. Bull. Woods Hole, Mass., LXXIV, 349—63, U. S. A., 1938.

Peacock, A. D. Oar-Fish at Westhaven, Angus. Scottish Naturalist, No. 232, 118—19, Edinburgh, 1938.

Pellegrin, J. Poissons rares du golfe de Gascogne du Musée de la Mer à Biarritz. Bull. Mus. Nation. d'Hist. Nat., 2e Sér., IX, 367—69, Paris, 1938.

Priol, E. P. Note sur les *Exocoetidae* de la cinquième croisière. Rev. Trav. Office des Pêches Marit., X, 357—69, Paris, 1937.

Priol, E. P. Note sur *Echeneis naucrates* Linée. Rev. Trav. Office des Pêches Marit., X, 371—78, Paris, 1937.

Roosen-Runge, E. C. On the Early Development — Bipolar Differentiation and Cleavage — of the Zebra Fish *Brachydanio rerio*. Biol. Bull. Woods Hole, Mass., LXXV, 119—33, U. S. A., 1938.

Schultz, L. P. A New Genus and Two New Species of Cottoid Fishes from the Aleutian Islands. Proc. U. S. Nation. Mus., LXXXV, 187—91, Washington, 1938.

Scott, E. O. G. Observations on Fishes of the Family Galaxiidae: Part 2. Pap. and Proc. Roy. Soc. of Tasmania for the Year 1937, 111—44, Hobart, 1938.

Turner, C. L. The Reproductive Cycle of *Brachyraphis episcopi* an Ovoviviparous Poeciliid Fish, in the Natural Tropical Habitat. Biol. Bull. Woods Hole, Mass., LXXV, 56—65, U. S. A., 1938.

6) b Distribution and Fluctuations.

Cadenat, J. Recherches systématiques sur les poissons littoraux de la côte occidentale d'Afrique, récoltés par le navire Président-Théodore-Tissier, au cours de sa 5e croisière (1936). Rev. Trav. Office des Pêches Marit., X, 425—562, Paris, 1937.

Kemp, S. Oceanography and the Fluctuations in the Abundance of Marine Animals. Brit. Assoc. Addresses, Section D. — Zool., 85—101, 1938.

Stephen, A. C. Temperature and the Incidence of Certain Species in Western European Waters in 1932—1934. Journ. Anim. Ecology, VII, 125—29, London, 1938.

6) c Physiology and Behaviour.

Bailey, B. E. Fish Oils. VII. The Pigments of Pilchard Oil. Journ. Fish. Res. Board Canada, IV, 55—58, Toronto, 1938.

Baldwin, E. Biochemistry of the Electric Organs of *Raia clavata*. Biochem. Journ., XXXII, 888—94, London, 1938.

Brocklesby, H. N. and Harding, K. F. Fish Oils. VIII. The Approximate Composition of the Fatty Acids of the Oil of Pilchards (*Sardinops caerulea*). Journ. Fish. Res. Board Canada, IV, 59—62, Toronto, 1938.

Cawston, F. G. Effects of Injury on the Teeth of *Selachii*. Nature, CXLII, 118, London, 1938.

Gillam, A. E. The vitamin A_1 and A_2 contents of mammalian and other animal livers. Biochem. Journ., XXXII, 1496—1500, London, 1938.

Huntsman, A. G. Overexertion as Cause of Death of Captured Fish. Science, N. S., LXXXVII, 577—78, U. S. A., 1938.

Lagabrielle, J. Contribution à l'étude anatomique, histologique et embryologique du thymus chez les Téléostéens. Stat. d'Aquic. et de Pêche de Castiglione 1936, 1er Fasc., I, Alger, 1938.

Lovern, J. A. Fat Metabolism in Fishes. XIII. Factors influencing the Composition of the Depot Fat of Fishes. Biochem. Journ., XXXII, 1214—24, London, 1938.

Matthews, S. A. The Seasonal Cycle in the Gonads of Fundulus. Biol. Bull. Woods Hole, Mass., LXXV, 66—74, U. S. A., 1938.

Needham, J. Contributions of Chemical Physiology to the Problem of Reversibility in Evolution. Biol. Rev. Cambridge Phil. Soc., XIII, 225—51, Cambridge, 1938.

Portier, P. Recherches de Physiologie comparée faites à bord de la "Princesse Alice". Résult. Camp. Sci. Monaco, XCVIII, Monaco, 1938.

Shorland, F. B. and Hilditch, T. P. The Component Fatty Acids of some New Zealand Fish Oils. Biochem. Journ., XXXII, 792—96, London, 1938.

Solberg, A. N. The Susceptibility of *Fundulus heteroclitus* Embryos to X-Radiation. Journ. Exper. Zool., LXXVII, 441—69, Philadelphia, 1938.

Sumner, F. B. and Doudoroff, P. Some Experiments upon Temperature Acclimatization and Respiratory Metabolism in Fishes. Biol. Bull. Woods Hole, Mass., LXXIV, 403—29, U. S. A., 1938.

Tirelli, M. Osservazioni sul systema di bottoni de senso e di papille del lato cieco del capo dei Soleidi, con particolare riguardo alla struttura delle papille. Biol. Zentralbl., LVIII, 333—40, Leipzig, 1938.

Wykes, U. The Control of Photo-Pigmentary Responses in Eyeless Catfish. Journ. Exper. Biol., XV, 363—70, London, 1938.

6) d Parasites and Diseases.

Bonham, K. and Guberlet, J. E. Notes on *Microcotyle sebastis* Goto from Puget Sound. Journ. Parasitol., XXIII, 281—90, 1937.

Guiart, J. Étude parasitologique et épidémiologique de quelques Poissons de mer. Bull. Inst. Océanogr., No. 755, Monaco, 1938.

7) Marine Fisheries.

7) a Commercial Fisheries: Statistical.

Anon. Statistiques des régions de pêche (année 1936, 2e semestre, année 1937, 1er semestre). Rev. Trav. Office des Pêches Marit., XI, 121—39, Paris, 1938.

Denmark. Fiskeri-Beretning for Aaret 1937. København, 1938.

Deraniyagala, P. E. P. The Fisheries of Ceylon. Colombo, 1932.

Kotthaus, A. Die Entwicklung und heutige Lage der jugoslavischen Grundschleppnetzfischerei. Fischmarkt, N. F., VI, 238—45, Cuxhaven, 1938.

Legendre, R. Le Poisson. Actual. Scient. et Indust. 633, Nutrition, XIV, Paris, 1938.

Norway. Norges Fiskerier 1936. Grandes Pêches maritimes. Norges Offis. Statist., IX, Oslo, 1938.

New Zealand. Report of the Sea Fisheries Investigation Committee 1937—38. Wellington, 1938.

Palestine. Report of the Chief Fisheries Officer of the Depart. of Agriculture and Fisheries of Palestine for the Year ended 31st March, 1937.

Schnakenbeck, W. Die Nordsee als Fischereigebiet. Fischmarkt, N. F., VI, 156—62, Cuxhaven, 1938.

Sweden. Fiske År 1936 av Statistiska Centralbyrån. Sveriges Offic. Statist., Stockholm, 1938.

Thiel, H. Neufundlandfischerei. Fischmarkt, N. F., VI, 212—18, Cuxhaven, 1938.

Tunis. Tableaux Statistiques des pêches maritimes en Tunisie. Années 1933, 1934, 1935, 1936. Stat. Océanogr. de Salammbô, Bull. Nos. 33, 35—37, Tunis, 1934, 1935, 1937.

Zolezzi, G. I nostri paesaggi e i nostri centri pescherecci. Boll. Pesca, Piscicolt. e Idrobiol., XIV, 283—92, Roma, 1938.

7) b Fish Technology.

Anon. Wasserstoffsuperoxyd als Frischhaltungsmittel für Seefische. Fischmarkt, N.F., VI, 185—89, Cuxhaven, 1938.

Beatty, S. A. Studies of Fish Spoilage. II. The Origin of Trimethylamine produced during the Spoilage of Cod Muscle Press Juice. Journ. Fish. Res. Board Canada, IV, 63—68, Toronto, 1938.

Boury, M. Remarques sur le salage du poisson destiné à être conservé en boîtes hermétiques chauffées. Rev. Trav. Office des Pêches Marit., XI, 107—9, Paris, 1938.

Brocklesby, H. N. and Green, K. The Preservation of Halibut Livers and Intestines. Progress Rep. Pacific Biol. Stat., etc., No. 36, 7—11, Prince Rupert, B. C., 1938.

Brocklesby, H. N. and Kuchel, C. C. The Removal of Vitamin A. from Oils by Soaps formed in Situ. Progress Rep. Pacific Biol. Stat., etc., No. 36, 14—15, Prince Rupert, B. C., 1938.

Carter, N. M. The Measurement of Herring Oil in Bulk. Progress Rep. Pacific Biol. Stat., etc., No. 36, 16—19, Prince Rupert, B. C., 1938.

Cercignani, A. Contributo alla ispezione sanitaria dei pesci. Infestione da larve di *Ascaris Capsularia* Rud. in merluzzo (*Gadus morrhua*) essiccato e salato (baccalà). Boll. Pesca, Piscicolt. e Idrobiol., XIV, 316—21, Roma, 1938.

Cooper, D. le B. Studies on Salt Fish. III. Equilibrium Moisture Coefficients of Salt Fish Muscle. Journ. Fish. Res. Board Canada, IV, 136—40, Toronto, 1938.

le Gall, J. Le fumage du Poisson. Rev. Trav. Office des Pêches Marit., XI, 59—106, Paris, 1938.

Gire, G. Le fer-blanc utilisé par les fabricants de conserves. Rev. Trav. Office des Pêches Marit., XI, 111—19, Paris, 1938.

Hasebe, A. Drying of the Frozen and Melted Fish. Japan. Soc. Scient. Fish., VII, 1—3, Tokyo, 1938.

Hurequin, L. L'utilisation des déchets de poisson dans les usines de conserve. La Pêche Marit., etc., XXI, 264—65, Paris, 1938.

Legendre, R. Le Poisson. Actual. Scient. et Indust. 633, Nutrition, XIV, Paris, 1938.

Notevarp, O. og Heen, E. Virkningen av frysehastighet, lagringstemperatur og råstoffets friskhet på kvaliteten av frossen fisk. Fiskeridirek. Skr., Ser. Teknolog. Unders., Rep. Technol. Res. concerning Norwegian Fish Industry, I, No. 2, 1—30, Bergen, 1938.

Roedel, P. M. Tuna Canning Methods in California. California Fish and Game, XXIV, 251—72, San Francisco, 1938.

7) c Fishing Vessels and Gear.

Anon. Mesh Experiments for Towing Nets. Part 2. Trawl Nets. Imp. Fish. Exper. Stat., No. 5, 1—7, Tokyo, 1938. (In Japanese).

Behuard, J. La Construction du Navire de Pêche. La Pêche Marit., etc., XXI, 297—98, Paris, 1938.

le Breton. J. F. La pêche électrique. La Pêche Marit., etc., XXI, 185—87, Paris, 1938.

Dijk, W. J. H. K. S. de Hoop. 1898—1938. 's-Gravenhage, 1938.

Hornell, J. The Fishing Boats of Hastings. Sussex County Mag., XI, 1—12, 1937.

Janssen, J. F. Air Bubbles as a Fish Scare. California Fish and Game, XXIV, 295—96, San Francisco, 1938.

Janssen, J. F. Rubber Floats for Nets. California Fish and Game, XXIV, 296, San Francisco, 1938.

7) d Fishing Grounds.

Kotthaus, A. Die Entwicklung und heutige Lage der jugoslavischen Grundschleppnetzfischerei. Fischmarkt, N. F., VI, 238—45, Cuxhaven, 1938.

8) Marine Fishery Investigations.

8) a Stocks and Effects of Fishing.

Anon. Can North Sea Fisheries be made profitable? Scientist tells how it is possible. Fishing News, 7, Aberdeen, 3-IX-38.

Anon. Science and the Fisheries. Lowestoft Naturalist tells of its Work. Fishing News, 19, Aberdeen, 1-X-38.

Bückmann, A. Über den Höchstertrag der Fischerei und die Gesetze organischen Wachstums. Ber. Deutsch. Wiss. Komm. f. Meeresf., N. F., IX, 16—48, Stuttgart, 1938.

le Danois, E. L'état actuel de la question de l'appauvrissement des fonds de pêche. Rev. Trav. Office des Pêches Marit., XI, 31—38, Paris, 1938.

Ford, E. Progress in Fisheries Research. Science Progress, XXXIII, 63—65, London, 1938.

8) b Cod.

Andersson, K. A. A Study of the Rate of Growth of some Fishes in the Baltic. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 67—72, Copenhague, 1938.

Eggvin, J. Oceanographical Conditions in North Norway connected with the Cod Fisheries. Fiskeridirek. Skr., Rep. Norwegian Fish. and Mar. Invest., V, No. 7, 33—46, Bergen, 1938. (In Norwegian, English résumé on page 51).

Frost, N. Some Fishes of Newfoundland Waters (with Notes on the Distribution of Eggs and Larvae). Res. Bull. No. 4, Dept. Nat. Resources, St. John's, Newfoundland, 1938.

Graham, M. Growth of Cod in the North Sea and Use of the Information. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 57—66, Copenhague, 1938.

Kändler, R. Untersuchungen über das Laichen des Ostseedorsches im Herbst. Kieler Meeresforsch., II, 272—92, Kiel, 1938.

McKenzie, R. A. Canadian Atlantic "Bank" Cod Migrations. Progress Rep. Atlantic Biol. Stat., etc., No. 22, 3—6, Canada, 1938.

McKenzie, R. A. Cod take smaller Bites in Ice-Cold Water. Progress Rep. Atlantic Biol. Stat., etc., No. 22, 12—14, Canada, 1938.

Poulsen, E. M. On the Growth of the Cod within the Transition Area. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 49—52, Copenhague, 1938.

Rollefsen, G. Age Analysis of the 1937 Catch of Cod. Fiskeridirek. Skr., Rep. Norwegian Fish. and Mar. Invest., V, No. 7, 23—32, Bergen, 1938. (In Norwegian, English résumé on page 49).

Rollefsen, G. Changes in Mean Age and Growth-Rate of the Year-Classes in the Arcto-Norwegian Stock of Cod. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 37—44, Copenhague, 1938.

Sund, O. Cod Tagging Experiments. Fiskeridirek. Skr., Rep. Norwegian Fish. and Mar. Invest., V, No. 7, Bergen, 1938. (In Norwegian, English résumé on page 47).

Sund, O. The Stock of Cod in 1937. Fiskeridirek. Skr., Rep. Norwegian Fish. and Mar. Invest., V, No. 7, 11—22, Bergen, 1938. (In Norwegian, English résumé on page 48).

Sund, O. On Diversity of Growth in Fish. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 33—36, Copenhague, 1938.

Tåning, Å. V. A Method for Cutting Sections of Otoliths of Cod and Other Fish. Journ. du Conseil, XIII, 213—16, Copenhague, 1938.

8) c Haddock.

Andersson, K. A. An Investigation into the Alterations in the Growth-Rate of the Haddock. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 85—88, Copenhague, 1938.

Carruthers, J. N. Fluctuations in the Herrings of the East Anglian Autumn Fishery, the Yield of the Ostend Spent Herring Fishery, and the Haddock of the North Sea — in the Light of relevant Wind Conditions. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 10—15, Copenhague, 1938.

Ogilvie, H. S. The Food of Post-Larval Haddock with References to the annual Fluctuations in the Haddock Broods. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 57—66, Copenhague, 1938.

Sund, O. On Diversity of Growth in Fish. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 33—36, Copenhague, 1938.

8) d Hake.

Belloc, G. Sur la présence du merlu dans les eaux de la presqu'île du Cap Vert. Rev. Trav. Office des Pêches Marit., X, 341—46, Paris, 1937.

8) f Plaice.

Andersson, K. A. A Study of the Rate of Growth of some Fishes in the Baltic. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 67—72, Copenhague, 1938.

Bückmann, A. Über das Wachstum der Nutzfische im Gebiet der Südlichen Nordsee. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 73—84, Copenhague, 1938.

Hickling, C. F. The English Plaice-Marking Experiments 1929—1932. Min. Agric. and Fish., Fish. Invest., Ser. II, XVI, No. 1, 1937, London, 1938.

Jensen, A. J. C. The Growth of the Plaice in the Transition Area. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 103—08, Copenhague, 1938.

Poulsen, E. M. On the Growth of the Baltic Plaice. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 53—56, Copenhague, 1938.

Ritchie, A. Preliminary Observations on the Food of the Plaice (*Pleuronectes platessa*) in Scottish Waters. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 49—56, Copenhague, 1938.

8) g Sole.

Bückmann, A. Über das Wachstum der Nutzfische im Gebiet der Südlichen Nordsee. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 73—84, Copenhague, 1938.

8) h Halibut.

Anon. Die Heilbuttfischerei in den Gewässern von Färöer, Island und Grönland. Fischmarkt, N. F., VI, 165—69, Cuxhaven, 1938.

Devold, F. The North Atlantic Halibut and Net Fishing. Fiskeridirek. Skr., Ser. Havunders., Rep. Norwegian Fish. and Mar. Invest., V, No. 6, 1—47, Bergen, 1938.

Jespersen, P. Statistical Survey of the Halibut Fishery in the Waters Round the Faroes, Iceland and Greenland. Medd. Komm. Danmarks Fisk.- og Havunders., Ser. Fiskeri, Bd. X, No. 5, København, 1938.

8) i Other Pleuronectidae.

Andersson, K. A. A Study of the Rate of Growth of some Fishes in the Baltic. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 67—72, Copenhague, 1938.

Bückmann, A. Über das Wachstum der Nutzfische im Gebiet der Südlichen Nordsee. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 73—84, Copenhague, 1938.

Cieglewicz, W. Size and Age Composition of Commercial Catches of the Flounder during the summer af 1937. Bull. Stat. Marit. de Hel, II, 57—62, Warszawa, 1938.

Cieglewicz, W. and Mulicki, Z. The Maturation of the Flounder (*Pleuronectes flesus*) and Composition of the Shoal of the Spawning Flounder in the Bay of Danzig. Arch. Hydrobiol. et d'Ichtyol., XI, 254—74, Suwalki, 1938. (In Polish, English résumé).

Molander, A. R. Investigations into the Growth-Rates of the Common Dab and the Flounder in the Southern Baltic. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 89—102, Copenhague, 1938.

Rae, B. B. Lemon Sole Larvae in Scottish Waters during 1931. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 42—48, Copenhague, 1938.

8) j Herring.

Andersson, K. A. A Study of the Rate of Growth of some Fishes in the Baltic. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb. CVIII, I, 67—72, Copenhague, 1938.

Bückmann, A. Über das Wachstum der Nutzfische im Gebiet der Südlichen Nordsee. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 73—84, Copenhague, 1938.

Carruthers, J. N. Fluctuations in the Herrings of the East Anglian Autumn Fishery, the Yield of the Ostend Spent Herring Fishery, and the Haddock of the North Sea — in the Light of relevant Wind Conditions. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 10—15, Copenhague, 1938.

Erdmann, W. Ein Beitrag zur Rassenfrage beim schottischen Frühjahrshering. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 31—36, Copenhague, 1938.

Erdmann, W. Die Deutsche Grosse Heringsfischerei im Jahre 1937. Ber. Deutsch. Wiss. Komm. f. Meeresf., N. F., IX, 1—15, Stuttgart, 1938.

Farran, G. P. The Herring Fisheries off the North Coast of Donegal. Dept. of Agric., Journal, XXXIV, No. 2, Dublin, 1938.

Frost, N. Some Fishes of Newfoundland Waters (with Notes on the Distribution of Eggs and Larvae). Res. Bull. No. 4, Dept. Nat. Resources, St. John's, Newfoundland, 1938.

Gilson, G. Variation of Year-Classes in an Annual Concentration of Fish. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 37—41, Copenhague, 1938.

Kokubo, S. and Tezuka, T. A Brief Observation on the Biology of Herring (*Clupea pallasii* C. and V.) which Migrates into Lake Obuchi, a Brackish Lake in Aomori Prefecture, Japan. Sci. Rep. Tohoku Imp. Univ., 4th Ser., Biol., XII, 639—70, Sendai, Japan, 1938.

Lea, E. A Modification of the Formula for Calculation of the Growth of Herring. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 13—22, Copenhague, 1938.

Ottestad, P. On the Relation between the Growth of the Fish and the Growth of the Scales. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 23—32, Copenhague, 1938.

Smith, W. C. The Manx Herring Shoals. Proc. and Trans. Liverpool Biol. Soc., LI, 22—70, Liverpool, 1938.

Tesch, J. J. Observations on the Herring Population in the Flemish Bight and the Eastern Part of the Channel in the Winter 1937—38. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 21—25, Copenhague, 1938.

Tester, A. L. Why collect Herring Statistics? Progress Rep. Pacific Biol. Stat., etc., No. 36, 5—6, Prince Rupert, B. C., 1938.

8) k Sardine and Other Clupeoids.

Demel, K. Quelques remarques sur les causes climatiques de l'absence des bancs de sprats dans le Golfe Dantzigois durant la saison hivernale 1937/38. Bull. Stat. Marit. de Hel, II, 25—39, Warszawa, 1938.

Dixon, B. The diminution of the Polish Sprat Catches in the Season 1937/38. Bull. Stat. Marit. de Hel, II, 44—53, Warszawa, 1938.

Dulzetto, F. Sui caratteri biometrici dell'acciuga *Engraulis encrasicholus* L. del Golfo di Catania. Boll. Pesca, Piscicolt. e Idrobiol., XIV, 180—209, Roma, 1938.

Hickling, C. F. Notes on the Biology of the Cornish Pilchard. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 26—28, Copenhague, 1938.

Höglund, H. Über die horizontale und vertikale Verteilung der Eier und Larven des Sprotts (*Clupea sprattus* L.) im Skagerak—Kattegatgebiet. Svenska Hydrogr.-Biol. Komm. Skr., Ny Ser.: Biol., Bd. II, Nr. 3, Stockholm, 1938.

Janssen, J. F. "Christmas Trees" in the California Sardine Fishery. California Fish and Game, XXIV, 178—84, San Francisco, 1938.

Robertson, J. A. The Sprat and the Sprat Fishery of England. Min. Agric. and Fish., Fish. Invest., Ser. II, XVI, No. 2, London, 1938.

Scofield, W. L. Sardine Oil and our Troubled Waters. California Fish and Game, XXIV, 210—23, San Francisco, 1938.

8) l Tunny and Mackerel.

Belloc, G. Sur la sexualité du germon et l'existence probable d'un lieu de ponte près de Madère. Rev. Trav. Office des Pêches Marit., X, 347—53, Paris, 1938.

Fick, H. Der deutsche Thunfischfang im Juli 1938. Fischmarkt, N. F., VI, 218—20, Cuxhaven, 1938.

Frade, F. Recherches biométriques sur la maturité sexuelle du Thon rouge. Trav. Stat. Biol. Marit. de Lisbonne, No. 41, Lisboa, 1936.

Frade, F. Recherches sur la maturité sexuelle du Thon rouge de l'Atlantique et de la Méditerranée. Trav. Stat. Biol. Marit. de Lisbonne, No. 42, Lisboa, 1938.

Godsil, H. C. The High Seas Tuna Fishery of California. Div. Fish and Game, Calif., Fish Bull. No. 51, Sacramento, 1938.

Godsil, H. C. Tuna Tagging. California Fish and Game, XXIV, 245—50, San Francisco, 1938.

Godsil, H. C. Tuna Tags. Journ. du Conseil, XIII, 217—20, Copenhague, 1938.

Huréquin, L. Les conserves de thon aux Etats-Unis. La Pêche Marit., etc., XXI, 161—62, Paris, 1938.

Thiel, H. Thunfisch und Thunfischfang. Fischmarkt, N. F., VI, 162—65, Cuxhaven, 1938.

Zolezzi, G. Notizie preliminari sulla biologia e sulla pesca dello *Scomber scomber* L. ligure. Boll. Pesca, Piscicolt. e Idrobiol., XIV, 41—61, Roma, 1938.

8) m Other Commercial Species.

Desbrosses, P. Sur le Saint-Pierre (*Zeus faber*) de Mauritanie, du Sénégal et de Guinée. Rev. Trav. Office des Pêches Marit., X, 379—409, Paris, 1937.

Desbrosses, P. Croissance et migrations du requin griset. Rev. Trav. Office des Pêches Marit., XI, 53—57, Paris, 1938.

Frost, N. Some Fishes of Newfoundland Waters (With Notes on the Distribution of Eggs and Larvae). Res. Bull. No. 4, Dept. Nat. Resources, St. John's, Newfoundland, 1938.

8) o Whales and Seals.

Anon. Antarctic Whaling. Polar Rec., No. 16, 121—22, Cambridge, 1938.

Anon. Protocol amending the International Agreement of June 8, 1937, for the Regulation of Whaling (with final act of the Conference) London, June 24, 1938. H. M. S. O., Miscellaneous No. 6, London, 1938.

Gauthier, H. Observations sur un cétacé du genre *Ziphius* mort au large d'Alger. Stat. d'Aquic. et de Pêche de Castiglione 1936, 1er Fasc., 181, Alger, 1938.

Iversen, T. Der Norwegische Robbenfang. Handb. Seefisch. Nordeuropas (Lübbert u. Ehrenbaum), VIII, H. 1b, 66—92, Stuttgart, 1938.

Mackintosh, N. A. Whales and Whaling. Nature, CXLII, 101—02, London, 1938.

Matsuura, Y. Statistical Studies of the Whale Foetuses. II. Humpback Whale in the Antarctic. Bull. Japan. Soc. Sci. Fish., VII, 72—74, Tokyo, 1938. (In Japanese, English résumé).

Matthews, L. H. The Sei Whale, *Balaenoptera borealis*. Discovery Rep., XVII, 183—290, Cambridge, 1938.

Peters, N. Über die Ernährung der südlichen Bartenwale. Natur und Volk, LXVIII, 124—30, Frankfurt a/M., 1938.

Portier, P. Recherches de Physiologie comparée faites à bord de la "Princesse Alice". Résult. Camp. Sci. Monaco, XCVIII, Monaco, 1938.

Pugsley, L. I. and Harding, K. F. Note on the Oils from the Hair Seal and Sea Lion. Progress Rep. Pacific Biol. Stat., etc., No. 36, 10—11, Prince Rupert, B. C., 1938.

Risting, S. und Paulsen, H. B. Der Norwegische Walfang. Handb. Seefisch. Nordeuropas (Lübbert u. Ehrenbaum), VIII, H. 1b, 1—66, Stuttgart, 1938.

Scharrer, E. Kleine Wal-Jagd in Kanada. Natur und Volk, LXVIII, 130—40, Frankfurt a/M., 1938.

Senner, P. La pêche à la baleine. La Pêche Marit., etc., XXI, 293—94, Paris, 1938.

Slijper, E. J. Die Sammlung Rezenter Cetacea des Musée Royal d'Histoire Naturelle de Belgique. Bull. Mus. Roy. d'Hist. Nat. de Belgique, XIV, No. 10, Bruxelles, 1938.

9) Freshwater Fisheries and Fishery Investigations.

9) a Salmonidae.

Anon. Gewinnung von Naturfutter für die Salmonidenbrut. Allg. Fisch. Zeit., LXII, 251—54, Augsburg, 1938.

Carl, C. A Spawning Run of Brown Trout in the Cowichan River System. Progress Rep. Pacific Biol. Stat., etc., No. 36, 12—13, Prince Rupert, B. C., 1938.

Dahl, K. A Review of Recent Salmon Marking Experiments in Norway. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, III, 3—16, Copenhague, 1938.

Davidson, F. A. and Christey, L. S. The Migrations of Pink Salmon (*Oncorhynchus gorbuscha*) in the Clarence and Sumner Straits Regions of Southeastern Alaska. Bull. Bureau Fish., XLVIII, 643—66, Washington, 1938.

Davidson, F. A. and Hutchinson, S. J. The Geographic Distribution and Environmental Limitations of the Pacific Salmon (Genus *Oncorhynchus*). Bull. Bureau Fish., XLVIII, 667—92, Washington, 1938.

Davis, H. S. Instructions for conducting Stream and Lake Surveys. U. S. Fish. Circ. No. 26, Washington, 1938.

Foerster, R. E. Predator Control in Relation to Sockeye Salmon Conservation. Progress Rep. Pacific Biol. Stat., etc., No. 36, 20—22, Prince Rupert, B. C., 1938.

Hartley, G. W. Salmon caught in the Sea, West Sutherland, 1937. Fisheries, Scotland, Salmon Fish., 1938, No. II, Edinburgh, 1938.

Huntsman, A. G. Sea Movements of Canadian Atlantic Salmon Kelts. Journ. Fish. Res. Board Canada, IV, 96—135, Toronto, 1938.

Macfarlane, P. R. C. Salmon of the Upper Solway District, 1934. Fisheries, Scotland, Salmon Fish., 1938, No. III, Edinburgh, 1938.

Menzies, W. J. M. Some Preliminary Observations on the Migrations of Salmon (*Salmo salar*) on the Coasts of Scotland. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, III, 17—35, Copenhague, 1938.

Mottley, C. McC. Fluctuations in the Intensity of the Spawning Runs of Rainbow Trout at Paul Lake. Journ. Fish. Res. Board Canada, IV, 69—87, Toronto, 1938.

Nall, G. H. Sea Trout of the River Carron and Loch Doule (Dhughaill), Western Ross-shire. Fisheries, Scotland, Salmon Fish., 1938, No. IV, Edinburgh, 1938.

Needham, P. R. and Vestal, E. H. Notes on Growth of Golden Trout (*Salmo aqua-bonita*) in two High Sierra Lakes. California Fish and Game, XXIV, 273—79, San Francisco, 1938.

Pritchard, A. L. Transplantation of Pink Salmon (*Oncorhynchus gorbuscha*) into Masset Inlet, British Columbia, in the Barren Years. Journ. Fish. Res. Board Canada, IV, 141—50, Toronto, 1938.

Pryce-Tannatt, T. E. Fish Passes in connection with Obstructions in Salmon Rivers. Buckland Lectures for 1937, London, 1938.

Reinwaldt, E. Salmon-Markings in Esthonia and the Results obtained up to the present date. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 29, Copenhague, 1938.

Ricker, W. E. A Comparison of the Seasonal Growth Rates of Young Sockeye Salmon and Young Squawfish in Cultus Lake. Progress Rep. Pacific Biol. Stat., etc., No. 36, 3—5, Prince Rupert, B. C., 1938.

Sato, R. On the Migratory Speed of Salmon and the Stock of Red Salmon calculated by the Tagging Experiments in Northern North Pacific. Bull. Japan. Soc. Sci. Fish., VII, 21—23, Tokyo, 1938. (In Japanese, English résumé).

Schindler, O. Über Larven und Jungfische der Kreuzungen zwischen Seesaibling und Bachsaibling. Internat. Rev. d. ges. Hydrobiol. usw., XXXVII, 385—404, Leipzig, 1938.

Taft, A. C. and Shapovalov, L. Homing Instinct and Straying among Steelhead Trout (*Salmo gairdnerii*) and Silver Salmon (*Oncorhynchus kisutch*). California Fisch and Game, XXIV, 118—25, San Francisco, 1938.

Wales, J. H. and Moore, M. Progress Report of Trout Feeding Experiments, 1937. California Fish and Game, XXIV, 126—32, San Francisco, 1938.

Went, A. E. J. Salmon of the River Shannon. Proc. Roy. Irish Acad., Sect. B, XLIV, 261—322, Dublin, 1938.

White, H. C. and Huntsman, A. G. Is Local Behaviour in Salmon heritable? Journ. Fish. Res. Board Canada, IV, 1—18, Toronto, 1938.

9) b Eels.

Athanassopoulos, G. Sur la montée d'Anguille en 1936—1937. Bull. Inst. Océanogr., No. 757, Monaco, 1938.

9) d Effects of Pollution.

Anon. Estuary of the River Mersey. The Effect of the Discharge of Crude Sewage into the Estuary of the River Mersey on the Amount and Hardness of the Deposit in the Estuary. Dept. Scient. and Ind. Res., Water Pollution Res. Tech. Paper No. 7, London, 1938.

Butcher, R. W., Longwell, J. and Pentelow, F. T. K. Survey of the River Tees. Part 3. The Non-Tidal Reaches — Chemical and Biological. Dept. Scient. and Ind. Res., Water Pollution Res. Tech. Paper No. 6, London, 1938.

Parker, A. River Pollution and Waste Waters from the Milk Industry. Nature, CXLI, 1039—41, London, 1938.

Smith, R. T. Cyanide Bearing Ore Mill Refuse as a Menace to Fish Life. Science N. S., LXXXVII, 552—53, U. S. A., 1938.

10) Shellfisheries.

10) a Molluscs.

Anon. Biologie ostréicole. La Pêche Marit., etc., XXI, 255—56, Paris, 1938.

Bonnot, P. Report on the California Oyster Industry for 1937. California Fish and Game, XXIV, 191—95, San Francisco, 1938.

Cole, H. A. A System of Oyster Culture. Journ. du Conseil, XIII, 221—35, Copenhague, 1938.

Dodgson, R. W. Shellfish and the Public Health. Public Health, London, June, 1937.

Galtsoff, P. S., Chipman, W. A., Hasler, A. D. and Engle, J. B. Preliminary Report on the cause of the Decline of the Oyster Industry of the York River, Va., and the effects of Pulp-Mill Pollution on Oysters. U. S. Bureau Fish., Invest. Rep. No. 37, Washington, 1938.

Havinga, B. Rijksinstituut voor Biologisch Visscherijonderzoek. Onderzoekingen over den broedval van oesters. Dept. Econ. Zaken, Afd. Visscherijen, Juli 1938, 9—14, 's-Gravenhage, 1938.

Lambert, L. Les coquillages comestibles et leur contrôle sanitaire. Rev. Trav. Office des Pêches Marit., XI, 39—43, Paris, 1938.

Loosanoff, V. L. and Engle, J. B. Chemical Control of Starfish. Science, N. S., LXXXVIII, 107—08, U. S. A., 1938.

Miyazaki, I. On a Substance which is contained in Green Algae and induces Spawning Action of the Male Oyster. (Preliminary Note). Bull. Japan. Soc. Sci. Fish., VII, 137—38, Tokyo, 1938.

Nichol, A. J. The Oyster-Packing Industry of Baltimore. Its History and Current Problems. Bull. Chesapeake Biol. Lab., 3—32, Solomons Island, Md., 1937.

10) b Crustacea.

Huréquin, L. Les conserves de crustacés. La Pêche Marit., etc., XXI, 301—02, Paris, 1938.

Nouvel, L. I. Quelques remarques sur la croissance et la mue du Homard des côtes de la Méditerranée. II. Observations sur la croissance d'une Langouste exotique. Bull. Inst. Océanogr., No. 752, Monaco, 1938.

Robertson, J. D. Some Features of the Calcium Metabolism of the Shore Crab (*Carcinus maenas* Pennant). Proc. Roy. Soc. London, Ser. B, CXXIV, 162—82, London, 1937.

Ruud, J. T. On the Norwegian Research Work concerning *Pandalus borealis*. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVII, 3ème Partie, 67—68, Copenhague, 1938.

Smith, G. F. M. The Size of Lobsters caught in the Southern Part of the Gulf of St. Lawrence. Progress Rep. Atlant. Biol. Stat., etc., No. 22, 9—10, Canada, 1938.

Thiel, H. Unter Krabbenfischern. Fischmarkt, N. F., VI, 276—78, Cuxhaven, 1938.

11) Miscellaneous.

11) a General.

Elmhirst, R. Food of the Otter in the Marine Littoral Zone. Scottish Naturalist, No. 232, 99—102, Edinburgh, 1938.

Fontaine, M. Rapport sur les recherches de chimie biologique effectuées à bord du navire "Président-Théodore-Tissier". Rev. Trav. Office des Pêches Marit., X, 339—46, Paris, 1937.

Hjort, J. Human Activities and the Study of Life in the Sea. An Essay on Methods of Research and Experiments. Geogr. Rev., XXV, 529—64, New York, 1935.

Hofmann, R. Unterwasser-Aufnahmen mit einer Tiefsee-Kamera in der Kieler Bucht. Kieler Meeresforsch., II, 352—53, Kiel, 1938.

Jacques, A. G. The Accumulation of Electrolytes. IX. Replacement of Ammonia by Sodium and Potassium. Journ. Gen. Physiol., XXI, 665—85, Baltimore, 1938.

Moffitt, J. and Orr, R. T. Recent disastrous effects of Oil Pollution on Birds in the San Francisco Region. California Fish and Game, XXIV, 239—44, San Francisco, 1938.

11) b Mathematical and Statistical Methods.

Buchanan-Wollaston, H. J. A Useful Statistical Test. Nature, CXLI, 160, London, 1938.

Buchanan-Wollaston, H. J. On the Application of the Statistical Theory of Space Distribution to Hydrographic and Fishery Problems. Journ. du Conseil, XIII, 173—86, Copenhague, 1938.

Ottestad, P. Notes on Statistical Methods of Growth Studies. Cons. Perm. Internat. p. l'Explor. de la Mer, Rapp. et Proc.-Verb., CVIII, I, 9—12, Copenhague, 1938.

Index to Volume XIII.

Articles.

Atkins, W. R. G., Clarke, G. L., Pettersson, H., Poole, H. H., Utterback, C. L. and Ångström, A. Measurement of Submarine Daylight 37
von Brand, Theodor. Quantitative Determination of the Nitrogen in the Particulate Matter of the Sea 187
Buchanan-Wollaston, H. J. On the Application of the Statistical Theory of Space Distribution to Hydrographic and Fishery Problems 173
Cole, H. A. A System of Oyster Culture 221
Farran, G. P. On the Size and Number of the Ova of Irish Herrings.. 91
Godsil, H. C. Tuna Tags 217
Graham, Michael. Rates of Fishing and Natural Mortality from the Data of Marking Experiments 76
Hentschel, Ernst. Über quantitative Seihmethoden in der Planktonforschung 304
Huntsman, A. G. International Passamaquoddy Fishery Investigations 357
Lisitzin, Eugenie. Über den Zusammenhang zwischen Wind und Strom bei dem Feuerschiff Storbrotten im nördlichen Ålandsmeer 293
Lucas, C. E. Some Aspects of Integration in Plankton Communities .. 309
Schach, Helmut. Ein Apparat zur Entnahme von Meerwasserproben aus der Tiefe für bakteriologische Untersuchungen 349
Seiwell, H. R. Eddy Diffusion at Mid-Depths in the Caribbean Sea Region 155
Steemann Nielsen, E. Über die Anwendung von Netzfängen bei quantitativen Phytoplanktonuntersuchungen 197
Sverdrup, H. U. On the Explanation of the Oxygen Minima and Maxima in the Oceans 163
Tåning, Å. Vedel. A Method for Cutting Sections of Otoliths of Cod and Other Fish 213
Tåning, Å. Vedel. The Migrations of Small Halibut Marked in Faroese Waters 370
Tester, Albert L. Variation in the Mean Vertebral Count of Herring (*Clupea pallasii*) with Water Temperature 71
Thamdrup, H. M. Der van Veen-Bodengreifer. Vergleichsversuche über die Leistungsfähigkeit des van Veen- und des Petersen-Bodengreifers 206
Tully, John P. The Expression of Sea-Water Analyses as Milligram-Atoms per Litre 67
Tully, John P. and **Carter, Neal M.** A Simplified Procedure for Colorimetric Analyses of Sea Water 58
van Veen, Joh. Water Movements in the Straits of Dover 7
Wimpenny, R. S. A Routine Method for the Estimation of Fat in Plankton and its Application to Herring Tissues 338
Wimpenny, R. S. Diurnal Variation in the Feeding and Breeding of Zooplankton related to the Numerical Balance of the Zoo-Phytoplankton Community 323

Reviews.

Bargmann, H. E. The Reproductive System of *Euphausia superba*. (M. V. Lebour) 116
Becker, R. Über den jährlichen Temperaturgang auf dem Atlantischen Ozean. (E. van Everdingen) 378
Bertin, L. Les Poissons Abyssaux du Genre *Cyema* Günther (anatomie, embryologie, bionomie). (E. Trewavas) 125
Bruun, A. F. Contributions to the Life Histories of the Deep Sea Eels: *Synaphobranchidae*. (E. Trewavas) 124
Church, P. E. Temperatures of the western North Atlantic from thermograph records. (G. Schott) 239
Clarke, G. L. On the Depth at which Fish can see. (H. H. Poole) .. 113
Clemens, W. A., Hart, J. L. and **Wilby, G. V.** Analysis of Stomach Contents of Fur Seals taken off the West Coast of Vancouver Island in April and May, 1934. (G. A. Steven) 260
Correns, C. W., Leinz, V. und **Radczewski, O. E.** Die Sedimente des äquatorialen Atlantischen Ozeans. 2. Lief. C. Zusammenstellung der Untersuchungsergebnisse nach Stationen geordnet. D. Auswertung der Ergebnisse. (John D. H. Wiseman) 386
le Danois, Ed., Beaugé, L., Belloc, G., Boury, M., Desbrosses, P., le Gall, J., Lambert, L., and **Rémy, D.** Die französische Seefischerei. (J. J. Tesch) 257
Darby, H. H., Johnson, E. R. F. and **Barnes, G. W.** Studies on the Absorption and Scattering of Solar Radiation in the Sea. (C. L. Utterback) 382
Deacon, G. E. R. The Hydrology of the Southern Ocean. (A. Defant) 102
Deacon, G. E. R. Note on the Dynamics of the Southern Ocean. (A. Defant) 102
Deutsche Seewarte. Bericht über die erste Teilfart der Deutschen Nordatlantischen Expedition des Forschungs- und Vermessungsschiffes "Meteor". Februar bis Mai 1937. (G. E. R. Deacon) .. 376
Dietrich, G. "Die dynamische Bezugsfläche", ein Gegenwartsproblem der dynamischen Ozeanographie. (H. U. Sverdrup) 244
Dodgson, R. W. Shellfish and the Public Health. (P. Bruce White). 410
Ellis, M. M. Detection and Measurement of Stream Pollution (F. T. K. Pentelow) 113
Erdmann, W. Ein neues Planktongerät für Horizontalfänge in verschiedenen Tiefen und seine Bedeutung für die praktische Fischerei (C. E. Lucas) 252
Fish, C. J. The Biology of *Calanus finmarchicus* in the Gulf of Maine and Bay of Fundy. (S. M. Marshall) 118
Fish, C. J. The Biology of *Pseudocalanus minutus* in the Gulf of Maine and Bay of Fundy. (S. M. Marshall) 118
Fish, C. J. The Biology of *Oithona similis* in the Gulf of Maine and Bay of Fundy. (S. M. Marshall) 118
Fish, C. J. and **Johnson, M. W.** The Biology of the Zooplankton Population in the Bay of Fundy and Gulf of Maine with special reference to production and distribution. (S. M. Marshall) .. 118
Foerster, R. E. The Relation of Temperature to the Seaward Migration of Young Sockeye Salmon (*Oncorhynchus nerka*). (F. T. K. Pentelow) 403
Ford, E. The Nations Sea-Fish Supply. (A. Bückmann) 256
Ford, E. Vertebral Variation in Teleostean Fishes. (H. Böker) .. 397
Fuller, J. L. and **Clarke, G. L.** Further Experiments on the Feeding of *Calanus finmarchicus*. (S. M. Marshall) 118
Galtsoff, P. S., Prytherch, H. F. and **Eagle, J. B.** Natural History and Methods of Controlling the Common Oyster Drills (*Urosalpinx cinerera* Say and *Eupleura caudata* Say). (F. S. Wright) 130

Garstang, W. On the size-changes of diatoms and their oceanographic significance. (E. Hentschel) 392
Gessner, Fr. Hydrographie und Hydrobiologie der Brackwässer Rügens und des Darss. (H. C. Redeke) 389
Gibbons, S. G. *Calanus finmarchicus* and other Copepods in Scottish Waters in 1933. (G. P. Farran) 247
Gudmundsson, F. Das Oberflächennetzplankton der isländischen Küstengewässer. (E. Steemann Nielsen) 253
Gurney, R. Larvae of Decapod Crustacea. Part IV. *Hippolytidae.* (M. V. Lebour) 117
Hansen, W. Die Strömungen im Barents-Meer im Sommer 1927 auf Grund der Dichteverteilung. (Håkon Mosby) 242
Hart, T. J. *Rhizosolenia curvata* Zacharias, an indicator Species in the Southern Ocean. (E. Hentschel) 116
Harvey, H. W. Note on selective feeding by *Calanus.* (E. Hentschel) 393
Hassard, A. Two Fish Passes on the River Shannon. (T. E. Pryce-Tannatt) 265
Hentschel, E. Zur quantitativen Planktonmethodik. (E. Steemann Nielsen) 254
Hentschel, E. Über den Ursprung der Heringsnahrung im Norden von Island. (E. Steemann Nielsen) 254
Hentschel, E. Naturgeschichte der nordatlantischen Wale und Robben. (F. C. Fraser) 261
Hessle, Chr. Undersökningar över strömningen i Stockholms skärgård. (Sven Runnström) 398
Hjort, J., Lie, J. and **Ruud, J. T.** Pelagic Whaling in the Antarctic. No. VI, the Season 1935—6. No. VII, the Season 1936—7, with a Preliminary Report on Variation in the Size Distribution of Blue and Fin whales, by Per Ottestad. (F. D. Ommanney) 407
Hopkins, A. E. Adaptation of the Feeding Mechanism of the Oyster (*Ostrea gigas*) to Changes in Salinity. (H. A. Cole) 127
Humphries, C. F. and **Frost, W. E.** River Liffey Survey. The Chironomid Fauna of the Submerged Mosses. (F. T. K. Pentelow) 268
Jakhelln, A. Oceanographic Investigations in East Greenland Waters in the Summers of 1930—1932. (G. Dietrich) 241
Jenkin, P. M. Oxygen Production by the Diatom *Coscinodiscus excentricus* Ehr. in Relation to Submarine Illumination in the English Channel. (S. M. Marshall) 394
Jensen, Ad. S. Den kinesiske Uldhaandskrabbe (*Eriocheir sinensis* M.-Edw.) i Danmark. (W. T. Calman) 396
Jensen, Ad. S. The Greenland Halibut (*Reinhardtius hippoglossoides* (Walb.)). Its Development and Migrations. (J. R. Norman) 259
Jespersen, P. The Food of the Herring in the Waters round Bornholm. (R. E. Savage) 122
Jurva, R. Über die Eisverhältnisse des Baltischen Meeres an den Küsten Finnlands nebst einem Atlas. (C. I. Speerschneider) 388
Kamps, L. F. De Chineesche Wolhandkrab in Nederland. (W. T. Calman) 396
Künne, Cl. Über die Verbreitung der Leitformen des Grossplanktons in der südlichen Nordsee im Winter. (C. E. Lucas) 250
Laurie, A. H. The Age of Female Blue Whales and the Effect of Whaling on the Stock. (Per Ottestad) 404
Lebour, M. V. The eggs and larvae of the British prosobranchs with special reference to those living in the plankton. (E. Hentschel) 393
Lebour, M. V. The newly hatched larva of *Spirontocaris spinus* (Sowerby) var. *lilljeborgi* Danielssen. (E. Hentschel) 393
Leloup, E. La propagation du crabe chinois en Belgique pendant l'année 1937. (W. T. Calman) 396
Lovern, J. A. Fat Metabolism in Fishes. VI. The Fats of some Plankton Crustacea. (R. S. Wimpenny) 254

Marchand, J. M. and **Taylor, W.** Savings-Trawl Investigations in South African Waters during 1935. (M. Graham) 123
Matthews, L. H. The Humpback Whale, *Megaptera nodosa.* (Johan T. Ruud) 405
Menzies, W J. M. The Movements of Salmon marked in the Sea. I. The North-west Coast of Scotland in 1936. (Knut Dahl) 264
Montgomery, R. B. Fluctuations in Monthly Sea Level on Eastern U.S. Coast as Related to Dynamics of Western North Atlantic Ocean. (G. Dietrich) 380
Moore, H. B. The Biology of *Purpura lapillus.* I. Shell variation in relation to environment. (J. H. Orton) 263
Mottley, C. McC. The Number of Vertebrae in Trout (*Salmo*). (F. T. K. Pentelow) 127
Newcombe, C. L. Growth of *Mya arenaria* L. in the Bay of Fundy Region. (F. S. Wright) 130
Norman, J. R. and **Fraser, F. C.** Giant Fishes, Whales and Dolphins. (E. Ehrenbaum) 262
Orton, J. H. Observations and Experiments on Sex-Change in the European Oyster, *Ostrea edulis* L. Part V. A simultaneous study of spawning in 1927 in two distinct geographical localities. (H. A. Cole) 128
Orton, J. H. Oyster Biology and Oyster Culture. (B. Havinga) .. 272
Orton, J. H., Jones, J. W. and **King, G. M.** The Male Sexual Stage in Salmon Parr (*Salmo salar* L. Juv.). (F. T. K. Pentelow) 402
Parr, A. E. Further Observations on the Hydrography of the Eastern Caribbean and Adjacent Atlantic Waters. (G. Dietrich) 381
Parr, A. E. On the Longitudinal Variations in the Dynamic Elevation of the Surface of the Caribbean Current. (A. Defant) 243
Pettersson, H. Eddy-Viscosity in Stratified Water. (S. E. Stenij).. 105
Pettersson, H. and **Malmheden, H. W.** Eddy-Viscosity in Stratified Water II. (S. E. Stenij) 105
Powell, W. M. and **Clarke, G. L.** The Reflection and Absorption of Daylight at the Surface of the Ocean. (H. H. Poole) 111
Proudman, J., Lewis, H. M. and **Dennis, A. L.** On the Temperature of the Surface Waters of the Irish Sea. (H. Thomsen) 107
Raitt, D. S. The Haddock Stocks of the North-East Atlantic, 1916—1935. (J. Lundbeck) 120
Rakestraw, N. W. The Occurrence and Significance of Nitrite in the Sea. (T. Braarud) 108
Rakestraw, N. W., Mahncke, H. E. and **Beach, E. F.** Determination of Iron in Sea Water. (L. H. N. Cooper) 110
Rakestraw, N. W. and **Smith, H. P.** A Contribution to the Chemistry of the Caribbean and Cayman Seas. (H. Wattenberg) 245
Ricker, W. E. The Food and the Food Supply of Sockeye Salmon (*Oncorhynchus nerka* Walbaum) in Cultus Lake, British Columbia. (F. T. K. Pentelow) 402
Ritchie, A. The Food and Feeding Habits of the Haddock (*Gadus aeglefinus*) in Scottish Waters. (E. M. Poulsen) 121
Robinson, R. J. and **Spoor, H. J.** Photometric Determination of Silicate in Sea Water. (L. H. N. Cooper) 110
Russell, F. S. On the Seasonal Abundance of Young Fish. V. The Year 1937. (G. P. Farran) 395
Russell, F. S. The Plymouth Offshore Medusa Fauna. (G. P. Farran) 394
Schaefer, M. B. Contribution to the Life History of the Surf-Smelt, *Hypomesus pretiosus,* in Puget Sound. (C. F. Hickling) 397
Schott, G. Die Aufteilung der drei Ozeane in natürliche Regionen. (H. U. Sverdrup) 379
Schott, G. Geographie des Indischen und Stillen Ozeans. (C. O'D. Iselin) 101

Seiler, R. Die Fütterung des Karpfens, beurteilt nach Aquarienversuchen. (M. Rosenberg) 400
Seiwell, H. R. Short Period Vertical Oscillations in the Western Basin of the North Atlantic. (A. Defant) 243
Seiwell, H. R. The Minimum Oxygen Concentration in the Western Basin of the North Atlantic. (G. Dietrich) 104
Smith, E. H., Soule, F. M., Mosby, O. The Marion and General Greene Expeditions to Davis Strait and Labrador Sea, 1928—1931—1933—1934—1935. Scientific Results, Part 2, Physical Oceanography. (Bruno Schulz) 237
van Someren, V. D. A Preliminary Investigation into the Causes of Scale Absorption in Salmon (*Salmo salar*, Linné). (F. T. K. Pentelow) 126
Spärck, R. Ringkøbing Fjords Naturhistorie i Brakvandsperioden 1915—1931. (H. C. Redeke) 269
Steemann Nielsen, E. The Annual Amount of Organic Matter produced by the Phytoplankton in the Sound off Helsingör. (T. Braarud) 115
Steuer, A. Biologische Sonderuntersuchungen. II. Lief. Die Verbreitung der Copepoden-Gattungen *Sapphirina, Copilia, Miracia, Pleuromamma, Rhincalanus* und *Cephalophanes* im Südatlantischen Ozean. (G. P. Farran) 248
Stoll, K. Beitrag zur Analyse der Stickstoffverbindungen im Meerwasser. (L. H. N. Cooper) 386
Suda, K. On the Method of the Practical Study of the Variations of the Oceanographical State of the Ocean and the Sea. (H. Thorade) 107
Suda, K. On the dissipation of Energy in the Density Currents. 2nd paper (H. Thorade) 106
Taylor, W. R. Marine Algae of the Northeastern Coast of North America. (L. Newton) 246
Tester, A. L. Some Results of the British Columbia Herring Investigation and their Economic Bearing. (Sven Runnström) 400
Thompson, W. F. Theory of the Effect of Fishing on the Stock of Halibut. (M. Graham) 255
Utterback, C. L. and **Jorgensen, W.** Scattering of Daylight in the Sea. (H. H. Poole) 111
Wattenberg, H. Kalkauflösung und Wasserbewegung am Meeresboden. (J. B. Tait) 384
Wattenberg, H. und **Timmermann, E.** Über die Sättigung des Seewassers an $CaCO_3$ und die anorganogene Bildung von Kalksedimenten. (J. B. Tait) 384
Webb, D. A. Studies on the Ultimate Composition of Biological Material Pt. II. Spectrographic Analysis of Marine Invertebrates, with Special References to the Chemical Composition of their Environment. (H. Ramage) 267
Wheeler, J. F. G. Further Observations on Lunar Periodicity. (C. F. Hickling) 409
White, K. M. Mytilus. (H. P. Sherwood) 264
Wilson, D. P. The Habits of the Angler-fish, *Lophius piscatorius* L., in the Plymouth Aquarium. (H. O. Bull) 260
Wimpenny, R. S. The Distribution, Breeding and Feeding of some important Plankton Organisms of the South-West North Sea in 1934. Part I. *Calanus finmarchicus* (Gunn), *Sagitta setosa* J. Müller), and *Sagitta elegans* (Verrill). (G. P. Farran) 249
Wohlenberg, E. Die Wattenmeer-Lebensgemeinschaften im Königshafen von Sylt. (H. M. Thamdrup) 390
Wüst, G. Bodentemperatur und Bodenstrom in der Pazifischen Tiefsee. (G. E. R. Deacon) 377

Notes and Correspondence.

Obituary Notices:—
Charles Green (1876—1938) by S. Kemp 3
K. Schøning (1860—1938) by W. Nellemose and Henry G. Maurice 151
Editorial Notice:— Appearance of the *Journal of Marine Research* 6

Errata:—
to "Solar Radiation and its Transmission through Air and Water" by W. R. G. Atkins, Vol. VII, No. 2, p. 181 236
to "Rates of Fishing and Natural Mortality from the Data of Marking Experiments" by M. Graham, this volume, pp. 86 and 89 150

Current Bibliography.

Current Bibliography prepared by the Editor with the assistance of Miss Thursby-Pelham ..... 132, 274, and 412

Recent Publications of the International Council:

RAPPORTS ET PROCÈS-VERBAUX.

Vol. No. 106: *Fluctuations in the Baltic Stock of Salmon (1921—1935)*, by T. H. Järvi. Mai 1938. Kr. 6.00.

Vol. No. 107: *Part I: Procès-Verbaux (Mai — 1938.)* Août 1938. Kr. 3.00.
Part II: Rapport Administratif (1937—1938). Août 1938. Kr. 3.00.
Part III: Appendices. Août 1938. Kr. 3.00.

Vol. No. 108: *Contributions to Special Scientific Meetings 1938.* Août 1938. Kr. 7.50.
Part I: Rate of Growth. Août 1938. Kr. 5.00.
Part II: Light Measurements. Août 1938. Kr. 1.00.
Part III: Salmon Migrations. Août 1938. Kr. 1.50.

BULLETIN HYDROGRAPHIQUE *pour l'année 1937.* In press.

BULLETIN STATISTIQUE *pour l'année 1936.* Septembre 1938. Kr. 3.00.

Attention is drawn to Series E:—

FAUNE ICHTHYOLOGIQUE DE L'ATLANTIQUE NORD, which is completed with the publication of No. 18, containing an alphabetically and systematically arranged Catalogue. Each number Kr. 4.00.

A detailed CATALOGUE covering all Publications of the Council is in the press.

Table of Contents.

		Page
1.	**Eugenie Lisitzin.** Über den Zusammenhang zwischen Wind und Strom bei dem Feuerschiff Storbrotten im nördlichen Ålandsmeer	293
2.	**Ernst Hentschel.** Über quantitative Seihmethoden in der Planktonforschung	304
3.	**C. E. Lucas.** Some Aspects of Integration in Plankton Communities	309
4.	**R. S. Wimpenny.** Diurnal Variation in the Feeding and Breeding of Zooplankton related to the Numerical Balance of the Zoo-Phytoplankton Community	323
5.	**R. S. Wimpenny.** A Routine Method for the Estimation of Fat in Plankton and its Application to Herring Tissues	338
6.	**Helmut Schach.** Ein Apparat zur Entnahme von Meerwasserproben aus der Tiefe für bakteriologische Untersuchungen	349
7.	**A. G. Huntsman.** International Passamaquoddy Fishery Investigations	357
8.	**Å. Vedel Tåning.** The Migrations of Small Halibut Marked in Faroese Waters	370
9.	Reviews	376
10.	Current Bibliography prepared by the Editor with the assistance of Miss **Thursby-Pelham**	412
11.	Index to Volume XIII	434

A/S L. IHRICH – COPENHAGEN